

# **MISSOURI STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION**



**1999**

Missouri Highways and Transportation Commission  
Jefferson City, Missouri



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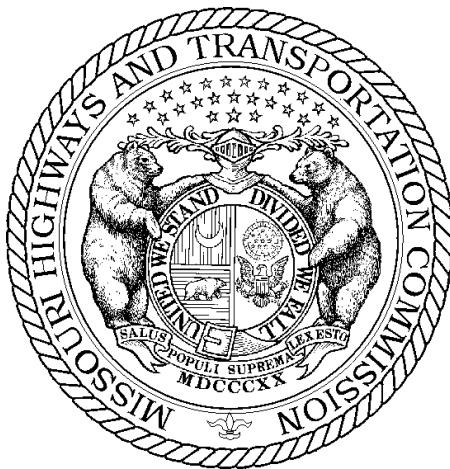
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I, Mari Ann Winters, as the duly appointed Secretary to the Missouri Highways and Transportation Commission, hereby certify the following specifications are a full, true and complete copy of the Missouri Standard Specifications for Highway Construction, 1999, as approved by the Missouri Highways and Transportation Commission at a lawful meeting on the 6th day of August, 1999.

Secretary





I, J. T. Yarnell, Chief Engineer of the Missouri Department of Transportation, hereby certify the following specifications are a full, true and complete copy of the Missouri Standard Specifications for Highway Construction, 1999, as approved by the Missouri Highways and Transportation Commission.

Chief  
Engineer





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# **DIVISION 100**

## ***GENERAL PROVISIONS***



## **SECTION 101**

### **DEFINITION OF TERMS**

Wherever the following abbreviations, terms or descriptive words are used in the plans, specifications or other contract documents, the intent and meaning shall be interpreted as follows:

#### **101.1 Abbreviations.**

<b>AAN</b>	American Association of Nurserymen
<b>AASHTO</b>	American Association of State Highway and Transportation Officials
<b>AGC</b>	Associated General Contractors of America
<b>ANSI</b>	American National Standards Institute
<b>AREA</b>	American Railroad Engineering Association
<b>ASME</b>	American Society of Mechanical Engineers
<b>ASTM</b>	American Society for Testing and Material
<b>AWPA</b>	American Wood-Preservers' Association
<b>AWS</b>	American Welding Society
<b>AWWA</b>	American Water Works Association
<b>CS</b>	Commercial Standards, U. S. Department of Commerce
<b>CSR</b>	Code of State Regulations
<b>DBE</b>	Disadvantaged Business Enterprise
<b>EEI</b>	Electrical Engineer's Institute
<b>EEO</b>	Equal Employment Opportunity
<b>EPA</b>	Environmental Protection Agency
<b>FHWA</b>	Federal Highway Administration
<b>ICEA</b>	Insulated Cable Engineers Association
<b>IMSA</b>	International Municipal Signal Association
<b>ITE</b>	Institute of Transportation Engineers
<b>MoDOT</b>	Missouri Department of Transportation

<b>MUTCD</b>	Manual on Uniform Traffic Control Devices
<b>NEC</b>	National Electrical Code, National Fire Protection Association
<b>NEMA</b>	National Electrical Manufacturers Association
<b>NESC</b>	National Electrical Safety Code
<b>NRMCA</b>	National Ready Mixed Concrete Association
<b>PS</b>	U. S. Product Standard, U. S. Department of Commerce
<b>QA</b>	Quality Assurance
<b>QC</b>	Quality Control
<b>RETMA</b>	Radio Electronics Television Manufacturer's Association
<b>SAE</b>	Society of Automotive Engineers
<b>USA</b>	United States of America

#### **101.1.1 Metric Symbols.**

<b>C</b>	celcius
<b>g</b>	gram
<b>h</b>	hour
<b>ha</b>	hectare
<b>j</b>	joules
<b>kg</b>	kilogram
<b>km</b>	kilometer
<b>km/h</b>	kilometer per hour
<b>kPa</b>	kilopascals
<b>L</b>	liter
<b>μ</b>	micro
<b>m</b>	meter
<b>m<sup>2</sup></b>	square meters
<b>m<sup>3</sup></b>	cubic meters
<b>Mg</b>	megagram
<b>mm</b>	millimeter
<b>mm<sup>2</sup></b>	square millimeters
<b>MPa</b>	megapascals
<b>N</b>	newtons
<b>N-m</b>	newton meter
<b>s</b>	seconds

#### **101.2 Definitions of Terms.**

**Advertisement.** The public announcement, as required by law, inviting bids for work to be performed or material to be furnished.

**Auxiliary Lane.** The portion of the roadway adjoining the traveled way and designated for speed change, or for other purposes supplementary to through traffic movement.

**Award.** The action of the Commission accepting the bid of the lowest responsible bidder for the work, subject to the execution and approval of a satisfactory contract therefore and bond to secure the performance thereof, and to such other conditions as may be specified or as required by law.

**Bid.** The written offer submitted by the bidder in the required manner on the bidding document to perform the work contemplated at contract bid prices.

**Bid Guaranty.** The security furnished with a bid to ensure that the bidder will enter into the contract if the bid is accepted.

**Bid Records.** All writings, working papers, computer printouts, charts and all other data compilation that contain or reflect information, data or calculations used by the bidder to determine each unit price in the bid submitted, including but not limited to material relating to the determination and application of:

- equipment rates
- home and field overhead rates and related time schedules
- labor rates
- efficiency or productivity factors
- arithmetic extensions
- subcontractors, truckers and material supplier quotations
- profit
- contingencies

Any manuals standard to the industry that are used by the bidder in determining the bid shall be included in the bid records by reference and shall show the name and date of the publication and the publisher.

**Bidder.** Any individual, partnership, corporation or joint venturer submitting a bid to perform the work contemplated.

**Bidding Documents.** The documents furnished by the Commission to be completed by the bidder and surety, based on the contract documents on which the bid prices and other pertinent information are to be submitted.

**Bridge.** A structure having a clear span greater than 20 feet (6.1 m) measured on a horizontal plane along the centerline of roadway; also a multiple span structure where the total length of spans is in excess of 20 feet (6.1 m). For both a single and multiple span bridge, the clear span shall be construed to mean the total distance from stream face to stream face of end bents or outer walls of the structure.

**Calendar Days.** Any day of the calendar year, including Saturdays, Sundays and legal holidays.

**Central Laboratory.** The central testing laboratory of the Commission for inspecting and determining the suitability of material.

**Change Order.** A written order from the engineer to the contractor, as authorized by the contract, directing changes in the work as made necessary or desirable by unforeseen conditions or events discovered or occurring during the progress of the work.

**Change in the Work.** An item of work not provided for in the contract as awarded but found essential to the satisfactory completion of the contract. See definition for significant change in the work.

**Commission.** The Missouri Highways and Transportation Commission.

**Contract.** The written agreement between the Commission and the contractor covering the performance of the work for the proposed construction. The contract shall include all contract documents. It may cover a single project or a combination of projects awarded as a single unit.

**Contract Bond.** The form of security approved by the Commission, furnished by the contractor and surety or sureties, guaranteeing complete performance of the contract and the payment of all legal debts pertaining to the construction of the project, and conditioned as may be required by the laws of the State of Missouri.

**Contract Documents.** Notice to Contractors, Plans, Bidding Document, Contract Bond, Contract Agreement, Acknowledgment, Contractor Questionnaire, Job Special Provisions, Standard Specifications, General Special Provisions, Notice to Proceed and all Supplemental Contracts and Change Orders.

**Contract Time or Completion Date.** The number of working days or calendar days shown in the bidding document as the time allowed for the completion of the work contemplated in the contract. If a calendar date for completion is shown in the bidding document, the work contemplated shall be completed by that date.

**Contractor.** The individual, partnership, corporation or joint venture undertaking performance of the work under the terms of the contract, and acting directly or through the contractor or contractor's agents, employees or subcontractors.

**Culvert.** A structure not classified as a bridge which provides an opening under any portion of a roadway.

**Days.** Days as used in the contract documents means calendar days unless specified otherwise.

**Delay.** Any event, action, force or factor that causes the established contract time to be exceeded for performance of the contract.

(a) **Compensable Delay.** An excusable delay for which the contractor may be entitled to additional monetary compensation

(b) **Excusable Delay.** A delay to the contract or milestone completion date that was beyond the contractor's control and not caused by the contractor's fault or negligence and for which a contract or milestone time extension may be granted.

(c) **Noncompensable Delay.** An excusable delay for which the contractor may be entitled to an extension of time but no additional monetary compensation.

(d) **Nonexcusable Delay.** A delay to the contract or milestone completion date that was reasonably foreseeable and within control of the contractor for which no monetary compensation or time extension will be granted.

**Differing Site Conditions.** Subsurface or latent physical conditions at the site differing materially from those indicated in the contract, or unknown physical conditions of an unusual nature differing materially from those ordinarily encountered and generally recognized as inherent in the work.



**Divided Highway.** A highway with separated traveled ways for traffic in opposite directions. Traveled ways separated by painted medians are not considered divided.

**Drainage Ditch.** An open depression constructed for the purpose of carrying off surface water.

**Engineer.** The chief engineer or any other authorized representative of the Commission. Where the term chief engineer is used it shall mean the chief engineer in person.

**Equitable Adjustment.** An adjustment in the contract price or time.

**Gender Related Terms.** No gender restrictions or limitations are intended or suggested by the use of terms "he", "him", "his", "it" or "its" in these specifications.

**Highway.** A public way for purposes of vehicular travel including the entire area within the right of way.

**Holidays.** Missouri public legal holidays are:

January 1 - New Year's Day  
Third Monday in January - Martin Luther King Day  
February 12 - Lincoln's Birthday  
Third Monday in February - President's Day  
May 8 - Truman's Birthday  
Last Monday in May - Memorial Day  
July 4 - Independence Day  
First Monday in September - Labor Day  
Second Monday in October - Columbus Day  
November 11 - Veterans Day  
Fourth Thursday in November - Thanksgiving Day  
December 25 - Christmas Day

When any of the above holidays fall on a Sunday, the holiday will be observed on the following Monday; when any of the above holidays fall on a Saturday, the holiday will be observed on the immediately preceding Friday.

**Laboratory.** The central testing laboratory of the Commission or any other testing laboratory which may be designated by the engineer for inspecting and determining the suitability of material.

**Lead Workers.** Hourly employees in direct charge of the specific operations on a project. Formerly referred to as the foremen.

**Local Traffic.** Traffic which has either its origin or its destination at some point within the limits of the project. Local traffic also includes that traffic on all side roads that lead into the project where such traffic does not have satisfactory outlet over a public road or street.

**Major and Minor Items of Work.** Any item having an original value in excess of 10 percent of the original contract amount shall be considered as a major item or items. All other original contract items are considered as minor. Where major contract items are not identified, the original contract item of greatest total cost, computed from the original contract price and estimated quantity, and such other original contract items next in sequence of lower total cost, computed in like manner, necessary to show a total cost at original prices and quantities of not less than 60 percent of the original contract cost shall be considered as a major item or items.

**Median.** The portion of a divided highway separating the traveled ways for traffic in opposite directions.

**Notice of Bid Opening.** The notification provided prospective bidders, containing a description of the proposed work, instructions, information and the reservation of the right of the Commission to reject any and all bids.

**Notice to Contractors.** The document contained in the bidding document describing the work to be performed and including information and requirements for the submission of bids.

**Notice to Proceed.** The written notice from the engineer notifying the contractor of the date on or before which prosecution of the work is to begin.

**Outer Roadway Or Service Road.** A roadway auxiliary to and located on the side of the throughway for service to abutting property and adjacent areas.

**Pay Item.** An item of work specifically described and for which a price, either unit or lump sum, is provided. It includes the performance of all work and the furnishing of all labor, equipment and material contemplated or described on the plans or in the text of the specification item included in the contract.

**Plans.** Drawings or reproductions thereof approved by the Commission, which show the location, character and details of the work.

**Project.** The specific section of the highway together with all appurtenances and construction to be performed thereon under the contract.

**Request for Bid.** The document furnished by the Commission which includes a complete set of bidding forms and appendices, and certain contract terms, which are made a part of the bidding document by reference.

**Right of Way.** Land acquired by the Commission for the construction and maintenance of a highway.

**Roadbed.** The graded portion of a highway between the outside shoulder lines including the base course, surface course, shoulders and median.

**Roadway.** The portion of the highway within limits of construction including bridges and other structures.

**Shoulder.** The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

**Significant Change in the Work.** When the character of the work, as altered, (1) differs materially in kind or nature from that involved or included in the original proposed construction or (2) when a major item of work as defined elsewhere in the contract is increased in excess of 125 percent or decreased below 75 percent of the original contract quantity.

**Specifications.** The compilation of provisions and requirements for the performance of prescribed work.

(a) Standard Specifications. A book of specifications approved for general application and repetitive use.

(b) General Special Provisions. Approved additions and revisions to the standard specifications.

(c) Job Special Provision. Revisions to the standard and general special provisions applicable to an individual project.

**State.** The State of Missouri, acting by and through the Commission.

**Subcontractor.** Any individual, partnership, corporation or joint venture to whom the contractor, with the written consent of the engineer, sublets any part of the work under the contract.

**Substructure.** That part of a bridge structure below the bearings of simple and continuous spans; all buttresses and piers below the skewbacks of arches; all parts of rigid frames, or integral bents below tops of footings or tops of caissons; and also, all parts of the abutments, backwalls and wingwalls, except handrail and handrail posts.

**Superstructure.** All parts of a bridge structure not defined as substructure.

**Surety.** A corporate body duly authorized to do business in the State of Missouri, and which has executed a bid bond with the bidder or a contract bond with the contractor.

**Temporary Structures.** Structures required for the use of traffic while construction is in progress and not to remain a part of the permanent roadway.

**Throughway.** A general term denoting a highway primarily for through traffic, usually on a continuous route.

**Through Traffic.** Traffic which has neither its origin nor its destination within the limits of the project.

**Traveled Way.** The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

**Unbalanced Bid, Materially.** A bid that generates a reasonable doubt that award to the bidder submitting a mathematically unbalanced bid will result in the lowest ultimate cost to the Commission.

**Unbalanced Bid, Mathematically.** A bid containing lump sum or unit bid items that do not reflect reasonable actual costs plus a reasonable proportionate share of the bidder's anticipated profit, overhead costs and other indirect costs.

**USA.** Any of the 50 states, the District of Columbia, Puerto Rico and any other territories and possessions of the United States of America.

**Work.** The furnishing of all labor, material, equipment and other incidentals necessary or convenient to the successful completion of the project and the carrying out of all the duties and obligations imposed by the contract.

**Working Drawings.** Stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel or any other supplementary plans or similar data which the contractor is required to submit to the engineer for approval.

## SECTION 102

### BIDDING REQUIREMENTS AND CONDITIONS

**102.1 Notice of Bid Opening.** After the date is fixed for the receipt of bids, the Commission may, in addition to the notice required by law, give notice of such date by mail directly to those contractors having on file with the Commission a valid contractor questionnaire. Others will be mailed notice of bid opening upon request and payment of a nominal subscription fee. The notice of bid opening will contain a description of the proposed work, together with instructions and information to the potential bidder regarding bid forms, plans, specifications, combination bids and the reservation of the right of the Commission to reject any and all bids.

**102.2 Contractor Questionnaire.** Each prospective bidder including a joint venture shall file a contractor questionnaire on forms furnished by the Commission. A bid will not be opened and read unless a fully responsive contractor questionnaire is on file with the Commission at least seven days prior to the time set for the opening of the bids. The contractor questionnaire shall be furnished to the Commission as a separate document apart from any other submitted. A new contractor questionnaire shall be filed annually except that the Commission reserves the right to request a contractor questionnaire from any contractor as of any date if the Commission has reason to believe that the contractor's experience data may have changed from that shown in the questionnaire than on file. This document shall include a record of the bidder's experience data. The Commission will use this information as an aid in determining in each instance the lowest responsible bidder, and nothing contained herein shall be construed as depriving the Commission of its discretion in the matter of determining the lowest responsible bidder.

**102.2.1** At any time prior to award, as a condition of award, and for a period of three years after the date of final acceptance, the Commission may request true copies of the bidder's financial data, including bidder's balance sheet, profit and loss statement, and similar or other financial data, as of the close of bidder's most recent fiscal year prior to submission of its bid, and for each fiscal year between the contract award and final acceptance of the contract work. Unless specified otherwise by the Commission, financial data shall be prepared by an accountant, and audited financial data shall be provided if it is available to the bidder for the fiscal period requested. A bidder who has not closed the first fiscal year prior to the date of the request shall supply the last periodic balance sheet, profit and loss statement and similar data.

**102.2.2** The contractor questionnaire also contains an affidavit of labor standards compliance. Each prospective bidder shall execute the affidavit, stating that such bidder will fully comply with all written requests by the Missouri Department of Labor and Industrial Relations, Division of Labor Standards, to provide information for the purpose of establishing a prevailing wage.

**102.2.3** The prospective bidder, if a corporation, shall submit with its contractor questionnaire a copy of its current annual registration report, or initial registration report if a new corporation, on file with the Corporation Division of the Missouri Secretary of State's Office. Each corporation which is a party to a joint venture shall submit the same required report with its joint venture contractor questionnaire.

**102.2.4** A prospective bidder doing business in the State of Missouri under a fictitious name shall furnish to or have on file with the Commission a certified copy of its registration of fictitious name issued by the Missouri Secretary of State, as an enclosure with its contractor

questionnaire. No contract will be executed by the Commission until such certificate is furnished by the bidder.

**102.2.5** All prospective bidders who are corporations organized in states other than Missouri shall furnish, at their cost, a certified copy of a current certificate of authority and license to do business in Missouri, said certificate to remain on file with the Commission. Such certified copy may be secured from the corporation supervisor in the office of the Secretary of State, Jefferson City, Missouri. The prospective bidder agrees to cause its authority and license to do business as a foreign corporation to be continued and extended throughout the life of any contract awarded, and until all claims thereon and thereunder shall have been finally settled.

**102.3 Bidding Documents.** Upon request, the Commission will furnish the bidding documents to the prospective bidder. The documents will state the location, description and requirements of the contemplated construction and will show the estimate of the various quantities and kinds of work to be performed or material to be furnished, and will have a schedule of items for which unit bid prices are invited. These documents include plans, standard specifications, special provisions and will state the time in which the work must be completed, the amount of the bid guaranty, and the date, time and place of the opening of bids.

**102.3.1** All papers bound with or attached to or referenced in the bidding documents are considered a part thereof and must not be detached or altered when the bid is submitted.

**102.3.2** The *Missouri Standard Specifications for Highway Construction*, *Missouri Standard Plans for Highway Construction* and other items referenced in the bidding documents, whether attached or not, will be considered a part of the bid.

**102.3.3** The prospective bidder will be required to pay the Commission the sum stated in the notice of bid opening for each copy of a project's bidding documents. A prospective bidder will be expected to separately purchase the current edition of the *Missouri Standard Specifications for Highway Construction* and the *Missouri Standard Plans for Highway Construction*.

**102.4 Interpretation of Quantities in Bid Schedule.** The quantities appearing in the bid schedule are estimated only and are prepared for the comparison of bids. Payment to the contractor will be made only for the actual quantities of work performed and accepted in accordance with the contract, except where final measurements are not made, as hereinafter provided. The quantities of work to be done and material to be furnished may each be increased, decreased or omitted as hereinafter provided.

**102.5 Examination of Plans, Specifications, Special Provisions and Site of Work.** The engineer will prepare plans and specifications providing the contractor with direction on the work required. Conditions indicated on the plans and in the bidding documents represent information available from surveys and studies. The bidder is expected to carefully examine the proposed work site and bidding documents before submitting a bid. Submission of a bid will be considered proof that the bidder has made an examination and is satisfied with the conditions to be encountered in performing the work.

**102.5.1** Other documentary information, consisting of boring logs and other factual subsurface information, which does not constitute part of the contract or contract documents, is available from the engineer upon the bidder's written request. This information, used for project design and quantity estimation purposes, was not obtained to determine actual subsurface conditions, actual quantities of subsurface material or appropriate construction methods, nor shall it be considered a representation of actual conditions to be encountered during construction. Furnishing this information does not relieve a bidder from the

responsibility of making an investigation of conditions to be encountered and basing their bid on information obtained from these investigation, or the professional interpretations and judgment of the bidder. The bidder assumes the risk of error if the information is used for any purposes for which it was not intended. The Commission makes no representation as to the accuracy of the logs or other subsurface information, since their accuracy is limited by the equipment used, the personal judgment of the persons making the investigation and by the limited number of samples taken. The records indicate conditions encountered only at the times and the specific locations shown. Ground water observations are not routinely recorded in all boring logs. The absence of such data does not mean ground water will not be encountered. An indication of ground water constitutes no representation or warranty as to where ground water will be found, nor its volume or artesian character, during the project work. Any assumptions a bidder may make from this data is at the bidder's risk; none are intended by the Commission.

**102.5.2** Certain other documents in the Commission's possession relating to subsurface investigations are not included in the records made available to bidders under [Sec 102.5.1](#). These include correspondence and reports containing interpretations, opinions and recommendations which may or may not be factual, accurate or consistent with design decisions. Any such information, which does not constitute part of the contract or contract documents, is available, at a nominal cost, from the engineer upon specific, written request of the prospective bidder. The bidder is cautioned that any and all such interpretations, conclusions and recommendations are not represented or warranted to be accurate or reliable, and the Commission cannot be bound by them, whether or not it may appear to have "relied" on them. These subjective findings, opinions or assumptions have not been confirmed or shown to be reliable, and the bidder assumes the sole risk of liability or loss if the bidder does rely on these documentary interpretations and conclusions to its detriment, delay or loss.

**102.5.3** The bidder assumes all risks it may encounter in basing its order of work, equipment or personnel determinations, time of performance, cost of performance, working days needed, item bid prices or any other element of the work, on documents which the bidder obtains from the Commission, which are not expressly warranted.

**102.5.4** Unless stated specifically and expressly in the bidding documents, no project involving excavation, which may include either borrow or the disposal of excess material, is represented or warranted to be a "balanced" job or project, regardless of whether the bidding documents use terms such as "balance points", or other terms which could be interpreted to suggest balance. Whether or not such projects involving excavation contain bid items for borrow or disposal of excess material, the bidder should assume that either are possible and investigate those possibilities accordingly in determining a bid.

**102.5.5** Utilities are often in the process of being relocated at the time a project is bid. Regardless of what utilities are shown in the bidding documents, and their locations listed, the bidder is responsible to contact each area utility to determine the presence and location of the utility lines. The bidder shall also determine, and shall assume the risk of its failure to determine, whether utilities which are to be relocated by the utility companies have in fact been relocated, and if not, when the utility company anticipates the relocation shall be completed. The bidder shall independently determine the reliability of the information received from the utility companies, and shall make its own determination as to the sequence and timing of utility relocations in determining its bid.

**102.6 Sales and Use Taxes.** The sales tax exemption for public works contractors of certain entities, enacted in 1994 in Section 144.062 RSMo, does not apply to contractors for the Commission or their subcontractors or suppliers. The Commission will not issue a sales tax exemption certificate to any contractor, subcontractor or supplier on any project. Contractors,

subcontractors or suppliers shall pay all applicable state and local sales taxes or state use taxes on all material and supplies used on a project and should include those taxes in their bid.

**102.7 Preparation of Bidding Documents.** All bids shall be properly signed and sealed, and submitted as set forth in [Sec 102.10](#). Each bidder shall specify in the bid, in figures, a unit price for each of the separate items listed in the bidding documents except a unit price entry is not necessary for those items having a quantity of one and only the amount for that item need be entered. The bid shall not contain interlineations, alterations or erasures except as noted in [Sec 102.7.1](#). The bidder shall show the products of the respective unit prices and quantities in the amount column provided for that purpose. These extensions shall be totaled and in case of errors or discrepancies in extensions, the unit prices shall govern. All entries in the bid shall be in ink. If, in the sole discretion of the engineer, an obvious and apparent clerical error exists in the unit price listed for an item due to a misplaced decimal, but the extension appears to be correct and as intended in all respects, the engineer may correct the unit price bid in accord with the extension listed. All errors in extensions or totals will be corrected by the engineer and such corrected extensions and totals will be used in comparing bids.

**102.7.1** A bidder may alter or correct a unit price, lump sum bid or extension entered on the bid form or the computer-generated itemized bid form by crossing out the figure with ink and entering a new unit price, lump sum bid or extension above or below in ink.

**102.7.2** A bidder may submit a separate bid on any or all projects except that bids must be submitted for all projects in a required combination. The bidder may specify in the bidding document the maximum monetary value of awards that will be accepted in the bid opening. The Commission reserves the right to make awards that will be to the best interest of the State, provided they are in conformance with the invitations for bids.

**102.7.3** The bid of an individual, including those doing business under a fictitious name, shall include the signature and address of the individual. The signature shall be exactly the same as that appearing on the contractor questionnaire.

**102.7.4** The bid by a partnership or joint venture, including individuals doing business under fictitious names, or corporations, shall be executed by at least one of the partners followed by the title "Partner", or one of the joint venturers followed by the title "Joint Venturer" and the business address of the partnership or joint venturer shown. The true legal name and address of each partner and joint venturer shall also be shown and shall appear exactly the same as that shown on the contractor questionnaire.

**102.7.5** The bid by a corporation, whether acting alone or as a joint venturer, shall show the address and name of the corporation exactly as shown on the contractor questionnaire and shall include the signature and title of a person authorized by its board of directors to bind the corporation.

**102.7.6** Each bidder shall submit with each bid a sworn statement, executed by or on behalf of the bidder to whom a contract may be awarded, certifying that the bidder has not, either directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action in restraint of free competitive bidding in connection with the bid, or any contract which may result from its acceptance.

**102.7.7** A bid will not be accepted or considered if it is the product of collusion among bidders, if the bidder is disqualified or determined not responsible, or if the bid is irregular as specified in [Secs 102.8](#) or [102.14](#).

**102.7.8 Computer-Generated Itemized Bids.** The bidder may utilize computer-generated itemized bid sheets.

**102.7.8.1** The computer-generated itemized bid sheets shall be 8.5" x 11" (216 mm x 279 mm). Any printer may be used provided the type is clear, distinct and legible. Any common typeface or font may be used except italic or script fonts. There shall be nine bid item lines per page, with a horizontal line separating each bid item. The header shall have the same information as the itemized bid sheets provided in the bidding documents and include the bidder's name. Each page of the computer-generated itemized bid shall match the itemized bid sheets provided in the bidding documents, line for line, including all section headings, sub-totals, totals for project and totals for combinations. Each page of the computer-generated itemized bidding documents shall match the itemized bid sheets provided in the bid, column for column, including all the line numbers, item numbers, descriptions, units and quantities. Abbreviations of item descriptions and units will be permitted provided sufficient wording is used to identify the item. The product of the bidder's unit price and the Commission's quantity for that same line number will be used in comparing bids and in the successful bidder's contract.

**102.7.8.2** An example of the bidder's computer-generated itemized bid sheet shall be submitted to the Commission for pre-approval no less than four weeks prior to the first bid opening in which it is used. Any revisions made to the bidder's approved computer-generated format shall be submitted to the Commission no less than four weeks prior to the bid opening for which the revised computer-generated itemized bid sheet is to be used.

**102.7.8.3** Any computer-generated itemized bid sheet not meeting the above requirements may cause the bid to be considered irregular and subject to rejection.

**102.7.8.4** The computer-generated itemized bid sheets shall be stapled together and attached to the last itemized bid sheet of the bid form. When the bidder submits computer-generated itemized bid sheets, the itemized bid sheets included in the bidding documents shall not be completed. If both are completed and submitted, only the computer-generated itemized bid sheets will be recognized and used as the official bid.

**102.7.8.5** When the bidder submits a computer-generated itemized bid for projects listed in a permitted combination, the bidder may include itemized bid sheets for all projects bid, and include sheets with only the header information and "NO BID" indicated for those projects not bid.

**102.8 Irregular Bids.** Bids that show any omissions, false statements or certifications, alterations of form, additions not called for, conditional or alternate bids unless called for, irregularities of any kind, or which are not responsive to the request for bids may be rejected. Bids combining or otherwise tying sections or projects not listed in the bidding documents as being in combination will be rejected. Any comment in the bid limiting or qualifying the reserved right of the Commission to make awards that will be to the best interest of the State shall constitute an irregular bid.

**102.8.1** A bid will be considered irregular and may be rejected as non-responsive if any of the unit bid prices are mathematically or materially unbalanced to the detriment of the Commission.

**102.8.2** A bid which is submitted by a bidder on the "Request For Bid" document and which is otherwise complete and fully executed, shall not be deemed an irregular bid, and shall not be subject to rejection by the Commission for that error alone.



**102.9 Bid Guaranty.** No bid will be considered unless accompanied by a certified check or cashier's check on any bank or trust company insured by the Federal Deposit Insurance Corporation, payable to the Director of Revenue, Credit State Road Fund, for not less than five percent of the amount of the bid, or by a bond secured by an approved surety or sureties as described in [Secs 103.4.2](#) and [103.4.3](#), for not less than five percent of the amount of the bid. Bid bonds shall be submitted on forms furnished by the Commission. Bid bond forms will be furnished to the prospective bidder upon request. Electronically produced copies of the bid bond form may be utilized. However, the exact wording used on the Commission furnished form must be included in full and without deviation. Bid bond forms must be complete and correct at the time of submittal or the bid may be considered non-responsive. Only the version of the bid bond form provided with the request for bid shall be submitted, unless the request for bid or notice of bid opening authorizes the use of alternate bid bond forms.

**102.9.1 Irregular Bid Guaranties.** Bids accompanied by bid guaranties which do not meet the requirements of [Sec 102.9](#) may be rejected. Those bids accompanied by bid bonds which are not issued by an approved surety will be rejected.

**102.10 Delivery of Bids.** Bid forms should be submitted with the bidding documents and submitted in the special envelope furnished by the Commission. The blank spaces on the envelope shall be filled in to clearly indicate its contents. If an envelope other than the special one furnished by the Commission is used, it shall be similarly marked clearly to indicate its contents. If sent by mail, the sealed bid shall be addressed to the Commission at the address specified in the bidding documents. All bids shall be filed prior to the time and at the place specified in the notice to contractors. Bids received after the time for opening of bids will be returned to the bidder unopened.

**102.11 Withdrawal or Revision of Bids.** A bidder may withdraw or revise a bid after it has been deposited with the Commission provided the revision or the request for such withdrawal is received in writing by the Commission, at the address specified in the bidding documents, before the time set for opening bids.

**102.12 Combination Bids.** Combination bids for two or more sections or projects of work may be made only if provided for in the bidding documents. On required combinations, a separate and complete bid for each section or project of work shall be included in the bid. On permitted combinations, the bidder will be allowed to combine sections or projects in the combination listed in the bidding documents as follows: (1) bidding on all sections or projects by stating "All or None", or (2) by listing any sections or projects desired to be bid, in which case each section or project will be considered separately.

**102.12.1** Two or more sections or projects bid in combination shall be considered to be covered by a single contract. If during construction an item for which a unit price has not been bid is encountered in one section or project of a combination, the unit price bid for the same item in another section or project of the combination shall apply, unless there is conclusive proof that conditions are changed significantly to effect a definite increase or decrease in the cost of the operation.

**102.13 Public Opening of Bids.** Bids will be opened and the bid totals read publicly at the time and place indicated in the notice to contractors.

**102.14 Disqualification of Bidders.** Any one or more of the following reasons may be considered as being sufficient for the disqualification of a bidder and the rejection of its bid or bids:

(a) More than one bid is received for the same work from an individual, firm or corporation under the same or different name, or from different firms or corporations having common ownership or control. However, a bidder may submit a bid as principal and as a subcontractor to some other principal, or may submit a bid as a subcontractor to as many other principals as the bidder desires, and by so doing will not be liable to disqualification in the intent of this specification.

(b) There is reason for believing that collusion exists among the bidders. Participants in such collusion will receive no recognition as bidders for any future work of the Commission until any such participant shall have been reinstated.

(c) The bidder, or any officer, shareholder, owner or director of the bidder, has been terminated, debarred or suspended as an eligible contractor or bidder by any agency of the United States, the State of Missouri or any other state, or any city, county, municipal corporation or other political subdivision.

(d) The Commission has determined or finds that the bidder is not responsible.

(e) The bidder is a person or firm not a resident of Missouri and has failed or refused to comply with the Missouri laws relating to nonresident or transient employers, or is prohibited by Section 285.230 RSMo from contracting for or performing labor on a Missouri public works project.

**102.15 Right to Reject Bids.** The Commission reserves the right to reject any bid and also the right to reject all bids.

**102.15.1** All bids may be rejected for, without limitation, the following reasons.

(a) If in the opinion of the majority of the members of the Commission, the lowest bid or bids shall be excessive.

(b) The advertised bidding or contract documents are inadequate, ambiguous or otherwise deficient in any respect.

(c) The construction of all or any part of the project is no longer required.

(d) The bids received indicate that the quality requirements in the bidding or contract documents were overstated.

(e) The bidding and contract documents did not include all of the intended evaluation factors.

(f) The bids were not independently arrived at in open competition.

(g) There are indications that any of the bids were collusive or were submitted in bad faith.

(h) The bids received did not provide sufficient competition to ensure adequate price.

## SECTION 103

### AWARD AND EXECUTION OF CONTRACT

**103.1 Consideration of Bids.** After the bids are opened and the bid totals read, they will be compared on the basis of the summation of the products of the approximate quantities shown in the bid schedule multiplied by the unit bid prices. The results of such comparisons will be immediately available to the public.

#### **103.2 Award of Contract.**

**103.2.1** The contract will be awarded by the Commission to the lowest responsible bidder as soon as practicable after the opening of the bids. The responsibility of the contractor will be determined by the Commission based upon, but not limited to, previous work, financial standing and record for the payment of the contractor's obligations. No contract will be executed by the Commission unless the contractor has on file with the Commission a valid contractor questionnaire as required by [Sec 102.2](#). The successful bidder will be notified by letter mailed to the address shown on the bid that the bid has been accepted and the contract has been awarded.

**103.2.2** By virtue of statutory authority, a preference will be given, on other than federal aid projects, to material, products, supplies, provisions and all other articles produced, manufactured, made or grown within the State of Missouri.

**103.2.3 Alternate Bids.** In making the award, if alternate bids have been requested, that alternate will be used which will be to the best interest of the State.

**103.2.4 Federal Concurrence.** If the federal government or any agency thereof is paying all or a portion of the cost of construction of the project, the award made by the Commission will be tentative until proper federal concurrence therein has been received.

**103.3 Return of Bid Guaranty.** The bid guaranty, whether check or bid bond, of the low bidder will be retained until the contract has been executed by the successful bidder, all insurance requirements met and satisfactory contract bond furnished. The check of the low bidder will then be returned. The bid guaranty of the second low bidder will be returned when the Commission has determined that the award will not be made to that firm. If errors or irregularities appear in the bid of either of the two apparent low bidders which create doubt as to the status of such bid, the bid guaranties of other bidders may be retained. When the two lowest bidders have been definitely established, the checks of the other bidders will be returned. Any bid bond furnished as a bid guaranty will be returned only upon request of the bidder furnishing it. If an award is not made, all checks will be returned to the bidders.

#### **103.4 Contract Bond Required.**

**103.4.1** The successful bidder shall, at the time of the execution of the contract, furnish a contract bond in a sum equal to the contract price. The bond shall be to the State of Missouri, in a form and with surety or sureties acceptable to the Commission, to ensure the proper and prompt completion of the work in accordance with the provisions of the contract and to ensure payment for all labor performed and material consumed or used in the work. The bond, if executed by a surety which is a corporation organized in a state other than Missouri, shall be signed by an agent or broker licensed by the Missouri Department of Insurance. All bids shall

be submitted on the basis of furnishing a contract bond executed by an approved surety or sureties, as herein set out.

**103.4.2 Certificate of Authority.** Any surety company which proposes to execute a bond as required by the contract shall have on file with or furnish to the Commission a certified copy of its certificate of authority to transact business in the State of Missouri.

**103.4.3 Surety Acceptability.** A surety is acceptable to the Commission if it is listed in the current "United States Department of the Treasury, Fiscal Service, Department Circular 570, Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies". Individual contract bonds may not be in excess of the underwriting limitation listed in the circular.

**103.5 Execution of Contract.** The individual, partnership, corporation or joint venturer awarded the contract shall return the prescribed copies of the contract and bond, properly executed, to the office of the Commission within fifteen days after the unexecuted contract has been mailed to the bidder. No bid shall be considered binding upon the Commission until the contract has been awarded by the Commission, and until the successful bidder has executed and returned the contract and a satisfactory bond. No contract shall be effective until it has been executed by all of the parties.

**103.6 Failure to Execute Contract.** Failure to execute the contract and to file an acceptable contract bond within fifteen days after the unexecuted contract has been mailed to the bidder shall be just cause for the cancellation of the award and the forfeiture of the bid guaranty. A bidder failing to file an acceptable bid or contract bond from an approved surety or failing to execute the contract within the time provided, resulting in a cancellation of the award to that bidder, disqualifies that bidder, and any other firm having common ownership or control with that bidder, from performing any work on the Commission project or projects which are the subject of that bid, as a prime contractor, a subcontractor or a supplier.

## SECTION 104

### SCOPE OF WORK

**104.1 Intent of Contract.** The contractor shall complete the work described and furnish all resources required to complete the work under the contract.

**104.2 Differing Site Conditions.** If differing site conditions are encountered during the progress of the work, the discovering party shall promptly notify the other party as specified in [Sec 104.4](#). No further disturbance of the site or performance of the affected work is to be done after the alleged differing site conditions are noted unless directed otherwise in writing by the engineer.

**104.2.1** Upon written notification, the engineer will investigate the conditions, and if it is determined that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the contract, an adjustment, excluding anticipated profits, will be made and the contract modified in writing accordingly. The engineer will notify the contractor whether or not an adjustment of the contract is warranted.

**104.2.2** No contract adjustment that results in a benefit to the contractor will be allowed unless the contractor has provided the required written notice as specified in [Sec 104.4](#).

**104.2.3** No contract adjustment will be allowed under this section for any effects caused on unchanged work.

**104.2.4** Payment will be determined under [Sec 109.4](#) and adjustments in contract time will be determined under [Sec 108.7](#).

**104.3 Changes in the Work.** The engineer reserves the right to provide written notice to the contractor, at any time during the contract, to change quantities or make other alterations for which there are no provisions included in the contract, considered necessary to satisfactorily complete the project. Such changes in quantities and alterations do not invalidate the contract nor release the contract surety, and the contractor agrees to perform the work as altered. Alterations of plans or of the nature of the work shall not involve work beyond the termini of the proposed construction, except as may be necessary to satisfactorily complete the project.

**104.3.1** If the alterations or changes in quantities do not cause a significant change in the work to be performed under the contract, payment for the altered work will be determined as provided in [Sec 109.3](#) for all work for which a contract unit price exists and [Sec 109.4](#) for all other work. The basis for the adjustment for work for which no unit price exists shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the contractor in such amount as the engineer may determine to be fair and equitable. If the directed changes require additional time to complete the contract, adjustments in the contract time will be determined under [Sec 108.7](#).

**104.3.2** If the alterations or changes in quantities cause significant change in the work under the contract as defined in [Sec 101](#), an adjustment, excluding anticipated profit, will be made to the contract. This adjustment shall occur whether such alterations or changes are in themselves a significant change in the work or by affecting other work cause such other work to become significantly different. Payment will be determined as provided in [Sec 109.3](#) or [109.4](#). The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the

contractor in such amount as the engineer may determine to be fair and equitable. If the directed changes require additional time to complete the contract, adjustments in the contract time will be determined under [Sec 108.7](#).

**104.4 Notification of Differing Site Conditions and Changes in the Work.** The contractor shall promptly notify the engineer of alleged changes to the contract due to differing site conditions, altered work beyond the scope of the contract or actions taken by MoDOT that changed the contract terms and conditions. Within five calendar days of the date the alleged change or action was noted, the contractor shall provide the following information to the engineer in writing:

- (a) The date of occurrence and the nature of circumstances of the occurrence.
- (b) The name, title and activity of knowledgeable MoDOT representatives.
- (c) The identity of any documents and the substance of any oral communications involved.
- (d) The basis for a claim of accelerated schedule performance.
- (e) The basis for a claim that the work is not required by the contract.
- (f) The particular elements of contract performance for which additional compensation, compensable or excusable delay may be sought under this section including:
  - (1) Pay items that have been or will be affected.
  - (2) Labor or material, or both, that will be added, deleted or discarded and what equipment will be idled, extended or required on the project.
  - (3) Delay and disruption in the manner and sequence of performance that has been or will be caused.
  - (4) Estimated adjustments to contract prices, delivery schedules, staging and contract time.
  - (5) Estimate of the time within which MoDOT must respond to the notice to minimize cost, delay or disruption of performance.

**104.4.1** For good cause the engineer may extend the time for the contractor to provide any part of the above information.

**104.4.2** The failure of the contractor to provide notice under [Sec 104.4](#) constitutes a waiver of any and all claims that may arise as a result of the allegations.

**104.5 Response to Notification of Differing Site Conditions and Changes in the Work.** Following submission of the [Sec 104.4](#) notification to the engineer, the contractor shall continue diligent prosecution of the work not affected by the notification, unless directed otherwise in writing by the engineer.

**104.5.1** Within ten calendar days after receipt of notification, the engineer will respond in writing to the contractor to:

(a) Confirm or deny that a change occurred and specify future action to be performed by the contractor and the engineer, or

(b) Advise the contractor that specific additional information is needed and the date it is to be received by the engineer for further review. For good cause the engineer may extend the time for the contractor to provide any of the additional information. The engineer will respond within ten days of receipt of additional information from the contractor. Any adjustments made to the contract shall not include increased cost or time extensions for delay if the contractor fails to provide the information required in the notice or the requested additional information by the date specified.

#### **104.6 Value Engineering.**

**104.6.1** The contractor is encouraged to submit to the engineer, in writing, proposals for modifying the plans, specifications or other requirements of the contract for the purpose of reducing the cost of construction. The modification proposed shall not impair, in any manner, the essential functions or characteristics of the project, including but not limited to service life, economy of operation, ease of maintenance, desired appearance or design and safety standards. Except as modified by [Sec 104.6.12](#), value engineering proposals shall contain the following information:

(a) A description of both the existing contract requirements for performing the work and the proposed changes.

(b) An itemization of the contract requirements that must be changed if the proposal is adopted.

(c) A detailed estimate of the cost of performing the work under the existing contract and under the proposed change.

(d) A statement of the time within which the engineer must make a decision thereon.

(e) The contract items of work affected by the proposed changes, including any quantity variation attributable thereto.

**104.6.2** Value engineering proposals which propose changes in the basic design of a bridge or a pavement, except for pavement and shoulder type, will be considered only when they will not significantly delay the completion of the project. The Commission will not be liable to the contractor for failure to accept or act upon any value engineering proposal nor for any delays to the work attributable to any such proposal.

**104.6.3** The contractor shall continue to perform the work in accordance with the requirements of the contract until a change order incorporating the value engineering proposal has been approved. If a change order has not been approved by the date upon which the contractor's value engineering proposal specifies that a decision thereon should be made, the proposal shall be deemed rejected unless the time allowed for a decision has been extended by mutual agreement of both parties.

**104.6.4** The engineer will be the sole judge of the acceptability of a value engineering proposal and of the estimated net savings in construction costs from the adoption of all or any part of such proposal. In determining the estimated net savings, the right is reserved to disregard the contract prices if, in the judgment of the engineer, such prices do not represent a fair measure of the value of work to be performed or to be deleted.

**104.6.5** The Commission reserves the right, if it deems such action appropriate, to require the contractor to share in the Commission's cost of investigating a value engineering proposal submitted by the contractor as a condition for considering such proposal. If such a condition is imposed, the contractor shall indicate acceptance thereof in writing, and such acceptance shall constitute full authority for the Commission to deduct amounts payable to the Commission from any monies due or that may become due to the contractor under the contract.

**104.6.6** All costs incurred by the Commission in evaluating the proposal will be deducted from the savings realized from approved value engineering proposals without prior acceptance from the contractor. The resulting figure will constitute the net savings.

**104.6.7** If the contractor's cost reduction is accepted in whole or in part, such acceptance will be by a change order which will specifically state that it is executed pursuant to [Sec 104.6](#). Such change order will incorporate the changes in the plans and specifications which are necessary to permit the value engineering proposal or such part of it as has been accepted to be put into effect, and will include any conditions upon which the Commission's approval thereof is based if the approval of the Commission is conditional. The change order will also set forth the price for performing those items of work affected by the change order and the estimated net savings in the cost of performing the work attributable to the value engineering proposal in the change order, and will further provide that the contractor will be paid 50 percent of the actual net savings of the construction cost at the completion of the work affected by the change order.

**104.6.8** The amount and time specified in the change order will constitute full compensation to the contractor for the value engineering proposal and the performance of that work.

**104.6.9** The Commission expressly reserves the right to adopt a value engineering proposal for general use on contracts administered by the Commission if it determines that said proposal is suitable for application to other contracts. If an accepted value engineering proposal is adopted for general use, only the contractor who first submitted such proposal will be eligible for compensation pursuant to this section and, in that case, only as to those contracts awarded to the contractor prior to submission of the accepted value engineering proposal. Value engineering proposals identical or similar to previously submitted proposals will be eligible for consideration and compensation under the provisions of [Sec 104.6](#) if the identical or similar previously submitted proposals were not adopted for general application to other contracts administered by the Commission or included in the present contract. Subject to the provisions contained herein, the State or any other public agency will have the right to use all or any part of any submitted value engineering proposal without obligation or compensation of any kind to the contractor, except as noted in [Sec 104.6.10](#).

**104.6.10** The contractor may request the return of information submitted with a value engineering proposal if the proposal is rejected. Such request must be in writing and be submitted with the proposal. If the proposal is accepted, this request shall be void and the Commission may use or disclose in whole or in part any information necessary to utilize the proposal.

**104.6.11** Prior to approval, the engineer may modify a proposal, with the concurrence of the contractor, to enhance it or make it acceptable. If any modification increases or decreases the net savings resulting from the proposal, the contractor's 50 percent share will be determined upon the basis of the proposal as modified.



**104.6.12** All proposals shall be submitted to the engineer with copies sent simultaneously to the Commission's appropriate district office, the Construction Division office and the value engineering administrator. If so desired, the contractor may submit a conceptual proposal for approval stating the basic proposal and approximate cost savings. The conceptual proposal will give the contractor the opportunity to submit an idea without large initial development costs should the proposal be rejected. Approval or disapproval of conceptual proposals or proposals having \$5000 total savings or less will be granted within ten calendar days of receipt of the proposal.

**104.6.13** The contractor is also encouraged to submit to the engineer, in writing, proposals for modifying the plans, specifications or other requirements of the contract for the purpose of providing a better product, improving safety or shortening the time required to complete the project. This specification is intended to include proposals that would not necessarily offer a reduction in cost or otherwise qualify under [Sec 104.6](#). The modification proposed shall not impair, in any manner, essential functions or characteristics of the project, including but not limited to service life, economy of operation, ease of maintenance, desired appearance, design or safety standards, and shall not significantly delay the completion of the project. Proposals shall be submitted to the engineer in advance of the work to be performed with sufficient time allowed for review. The Commission will not be liable to the contractor for failure to accept or act upon the proposal nor for any delays to the work attributable to any such proposal.

#### **104.7 Maintenance of Traffic Operations During Construction.**

**104.7.1** Provision for local traffic shall be made by the contractor, at the contractor's expense, at all times during construction, unless otherwise specified in the contract.

**104.7.2** The contractor will be required to maintain all traffic over the project, at the contractor's expense, unless otherwise specified in the contract.

**104.7.3** If detours for through traffic are to be provided by the Commission at its expense or designated on the plans to be constructed and maintained by the contractor around the entire project or any major portion of the work during construction, the engineer may open for use by traffic any uncompleted portions of the project and will have the option either to maintain such portions with Commission forces or to require the contractor to maintain them. If the contractor is required to maintain such opened portions, the contractor will be reimbursed for the cost of such maintenance in accordance with [Sec 109.4](#). However, when the time set for completion, together with any authorized extension of time, has elapsed, the contractor shall be responsible for all further costs of maintaining such opened portions, whether they are maintained by the contractor's forces and equipment or by Commission forces.

**104.7.4** If the contractor is required to maintain traffic over the project, whether on constructed detours or on bypasses, such maintenance shall be construed to mean the satisfactory handling of all traffic to maintain safe and substantially uninterrupted flow. The contractor shall also maintain the roadbed substantially free of ruts, holes and detrimental surface deformations. The contractor shall control the height of vegetation for the traffic safety, and provide and maintain in a safe condition approaches, crossings and intersections with abutting property to the highway, railroads, trails, roads and streets. Such maintenance shall be performed as necessary from the day the contractor starts construction operations under the contract. Snow removal will not be required of the contractor.

**104.7.5** When it is to the advantage of the Commission, projects involving pavement may be opened to traffic as soon as the surface has been sufficiently cured, even though the shoulders and other items of work may not be completed. Such projects or portions of projects will be

inspected and a partial acceptance made as to the work completed, and the contractor will be required to complete any remaining construction items under traffic.

**104.7.6** When the engineer opens for use by traffic any unfinished portions of the project as provided under [Sec 104.7.3](#) or [104.7.5](#), the contractor will be compensated as provided by [Sec 109.4](#) for any documented actual additional costs approved by the engineer. Any documented inefficiencies, delays or other time related effects approved by the engineer will be an excusable delay only, as provided by [Sec 108.14](#).

**104.7.7** The contractor may be directed by the engineer to repair permanent facilities of the Commission which have been damaged by events which are beyond the control of the contractor. The contractor shall immediately give written notice to the engineer of any pedestrian or vehicular accident that results in damage to permanent facilities of the Commission. If directed by the engineer, the contractor shall pursue the recovery of any repair costs from the responsible third person. To the extent the contractor is unable to recover the repair costs, reimbursement will be provided by the Commission under [Sec 109.4](#) for the actual direct cost of labor, equipment and material, exclusive of overhead, indirect or consequential costs or profit. Prior to reimbursement, the contractor shall furnish documentary evidence of all efforts to recover such repair costs. The Commission may elect to make such repairs in lieu of the contractor.

**104.8 Surfacing for Temporary Use.** Surfacing for the temporary use of traffic shall, when directed by the engineer, be applied to areas necessary to provide satisfactory ingress and egress to private property, across the project or along the roadway. Such surfacing will be authorized if traffic cannot be handled satisfactorily by the contractor maintaining a reasonably smooth and drainable earth surface in accordance with [Sec 104.7](#). The quantity, quality and type of surfacing will be designated by the engineer. Acceptance of the material will be based on visual examination.

**104.8.1** Measurement of material furnished for temporary surfacing will be made in accordance with [Sec 310.4.2](#), excluding any deductions for moisture.

**104.8.2** The quantity of surfacing for temporary use authorized and accepted will be paid for at the unit price indicated in the contract. Regardless of overruns or underruns, no adjustment will be made in the price for this material.

**104.8.3** No direct payment will be made for preparing a subgrade, spreading or laying surfacing for temporary use, maintaining the surfacing, or future removal or scarifying if necessary.

**104.9 Rights In and Use of Material Found on the Work.** The contractor, with the written approval of the engineer, may use in the construction of the project any stone, gravel or sand found in the excavation which conforms to the requirements of the specifications for material. It is expressly understood, however, that the Commission will not pay for damages or for anticipated profits on account of the expected use of any material shown upon the plans as existing and later found to be nonexistent or unfit for use. Payment will be made to cover the removal of such material at the contract unit price for excavation of the classification under which it properly belongs. If such material is used instead of material that was to have been furnished at the expense of the contractor under the terms of the contract, the contractor shall furnish sufficient suitable material, at no additional expense to the Commission, to complete the roadway. Unless authorized in writing by the engineer, the contractor shall not excavate or remove from within the right of way any material which is not within the excavation limits as indicated by the slope and grade lines.

#### **104.10 Mailboxes, Signs and Markers.**

**104.10.1 Mailboxes.** Mailboxes within the limits of operations shall be removed by the contractor before work is begun. They shall be set temporarily where they will be accessible to both the carrier and the patron, and shall be properly reset by the contractor at designated locations before final acceptance of the work by the Commission. Mailboxes damaged by the contractor shall be replaced by the contractor. All mail box supports set by the contractor shall comply with AASHTO guidelines. Mailboxes may be reset by the contractor using only approved supports furnished either by the postal patron or by the engineer. No direct payment will be made for the removal, relocation or replacement of mailboxes or supports.

**104.10.2 Signs and Markers.** Signs and markers within the limits of operations shall be removed by the contractor before work is begun. All such signs and markers required for safe control and guidance of traffic shall be temporarily reset where they are readily visible to traffic, and shall be maintained in a satisfactory condition. If the nature of the work makes temporary relocation impractical, the signs shall be placed on movable supports and maintained properly. Stop and yield signs at intersecting roadways shall be maintained where they are readily visible to traffic at all times. Other individual signs may be moved aside only when they interfere with actual operations. All required signs and markers must be properly located to control traffic at all times. Final removal of signs and markers will be permitted only when permanent signs and markers have been installed. All signs and markers remain the property of the Commission and shall, after final removal, be delivered without damage to one or more locations within the project limits as directed by the engineer. No direct payment will be made for removal, relocation, temporary supports, maintenance or final removal and delivery of signs and markers.

**104.10.3 Right of Way Markers and Plaques.** All right of way marker posts or markers damaged by the contractor's operations shall be replaced at the contractor's expense and installed in accordance with [Sec 602](#) and the standard plans. Replacements for damaged right of way marker plaques will be furnished by the Commission.

#### **104.11 Final Clean Up.**

**104.11.1** Before final acceptance, the contractor shall restore in an acceptable manner all property, both public and private, which may have been damaged on account of prosecution of the work, and shall leave the right of way neat and presentable. All areas beyond the limits of construction which have been damaged by the contractor's operations shall be restored by the contractor at the contractor's expense as directed by the engineer.

**104.11.2** When specified in the contract, the contractor shall open and clean all existing channels and culverts leaving them free from all excess mud or silt, drift, brush or debris of any kind. Any material excavated in cleaning existing channels will be paid for as roadway excavation of like classification. Any material excavated in cleaning out culverts which are used in place will be paid for at the contract price per each structure. However, only the initial excavation will be paid for, and any subsequent cleaning required prior to final acceptance shall be done at the contractor's expense.

#### **104.12 Requirements for Projects Involving Work Upon Railroad Right of Way.**

**104.12.1** All work upon, over or under railroad right of way shall be performed by the contractor without damage to the facilities and property of the railroad or its lessees, and in strict observance of requirements of the engineer and railroad for the safety of railroad property and operations. The contractor shall be responsible for maintaining the existing or proposed depth and section of the ditches along the tracks of railroads through the limits of

construction. Any sediment resulting from the new construction shall be promptly removed to avoid the possibility of filling the ditches, obstructing drainage or fouling the ballast.

**104.12.2** The work performed upon, over or under railroad right of way shall be subject to the inspection of railroad representatives.

**104.12.3** The Commission will make provisions for any temporary removal of railroad or railroad lessees' facilities which are to be moved.

**104.12.4** The contractor shall in no way hold the Commission liable for delay caused by securing the railroad company's approval of construction features involved in placing any grade separation structure or any changes from the design plans which appear desirable during construction.

**104.12.5** No direct payment will be made for complying with the requirements of this section.

**104.13 Warranty.**

**104.13.1** On all contracts requiring the contractor to furnish and install electronic, electrical or mechanical equipment, the contractor shall obtain, assign and furnish to the Commission written manufacturer's warranties for all such equipment consistent with those provided as customary trade practice. Additionally, a contractor's warranty providing for satisfactory in-service operation shall be provided for a minimum period of six months from the date of project acceptance.

**104.13.2** If the equipment fails to perform satisfactorily for the specified length of time, the manufacturer or the contractor shall replace or repair the equipment as necessary to restore required performance. MoDOT labor costs resulting from equipment replacement will not be charged to the manufacturer or the contractor.

**104.13.3** No direct payment will be made for complying with the requirements of this section.

## SECTION 105

### CONTROL OF WORK

#### 105.1 Authority of the Engineer.

**105.1.1** The engineer will decide all questions which may arise as to the quality, quantity and acceptability of material furnished and work performed and as to the rate of progress of the work; all questions which may arise as to the interpretation of the plans and specifications; all questions as to the acceptable fulfillment of the contract on the part of the contractor; all questions of classification; the proper compensation for the performance or breach of the contract; all claims of any character whatsoever in connection with or growing out of the construction whether claimed under the contract, under force account, under quantum merit or otherwise; and the estimates and decisions shall be final, binding and conclusive upon all parties to the contract.

**105.1.2** The engineer has the authority to suspend the work wholly or in part in accordance with these provisions. The suspension may be given verbally, but will be followed in writing immediately.

(a) The engineer may suspend the work wholly or in part for the contractor's failure to:

- (1) Correct conditions unsafe for the project personnel or general public.
- (2) Carry out provisions of the contract.
- (3) Carry out orders of the engineer.

Such suspension shall be nonexcusable and noncompensable.

(b) Work may also be wholly or partially suspended for:

- (1) Periods necessary due to unsuitable weather.
- (2) Conditions considered unsuitable for the prosecution of the work.
- (3) Any condition or reason determined to be in the public interest.

Such suspension may be excusable and may be compensable as determined by the engineer as provided by [Sec 108.15](#).

**105.2 Plans and Working Drawings.** The plans will be supplemented by such working drawings as are necessary to adequately control the work. Working drawings for structures shall be furnished by the contractor and shall consist of such detailed plans as may be required to adequately control the work and which are not included in the plans furnished by the Commission. Required working drawings must be approved by the engineer and such approval shall not relieve the contractor of any responsibility under the contract for the successful completion of the work.

**105.3 Conformity with Contract Documents.** All work performed and all material furnished shall be in conformity with the lines, grades, cross sections, dimensions and material requirements, including tolerances, shown in the contract documents.

**105.3.1** If the engineer finds the material or the finished product in which the material was used is not in conformity with the contract documents but that reasonably acceptable work has been produced, a determination will be made if the work will be accepted and remain in place.

In this event, the engineer will document the basis of acceptance by contract modifications which may provide for an appropriate adjustment in the contract price for such work or material as deemed necessary to conform to the determination based on engineering judgment.

**105.3.2** If the engineer finds the finished product to be unacceptable as a result of the contractor's method of operation or the use of unacceptable material, the work shall be removed and replaced or otherwise corrected by and at the expense of the contractor.

**105.4 Coordination of Contract Documents.** The contract documents are essential parts of the contract, and a requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete work. In case of discrepancy among contract documents, the governing ranking will be:

- (a) Job Special Provisions
- (b) General Special Provisions
- (c) Plans
- (d) Standard Drawings
- (e) Standard Specifications
- (f) Bid Items or Quantities

In case of discrepancy, calculated dimensions will govern over scaled dimensions.

**105.4.1** The contractor shall not take advantage of any apparent error or omission in the contract documents. If an error or omission is discovered, the engineer shall be notified promptly so corrections and interpretations necessary to fulfill the intent of the contract can be made. A failure to give notice shall render the effects of any error or omission noncompensable and any delay nonexcusable. This section shall apply to all bidders.

**105.5 Cooperation by Contractor.** The contractor shall maintain one set of contract documents at the work site at all times.

**105.5.1** The contractor shall give the work the constant attention necessary to facilitate the progress thereof, and shall cooperate with the engineer and other contractors in every way possible.

**105.5.2** The contractor shall have on the work at all times, as the contractor's agent, a competent individual capable of reading and thoroughly understanding the plans and specifications and thoroughly experienced in the type of work being performed, whom shall receive instructions from the engineer. That individual shall have full authority to execute orders or directions of the engineer without delay, and to promptly supply such material, equipment, tools, labor and incidentals as may be required.

**105.6 Cooperation Between Contractors.** The Commission reserves the right at any time to contract for and perform other or additional work on or near the project limits covered by the contract.

**105.6.1** If separate contracts are awarded within the limits of any one project, each contractor shall conduct work so as not to interfere with or hinder the progress or completion of the work

being performed by other contractors. Full cooperation of the contractors involved, in careful and complete coordination of their respective activities in the area, shall be required.

**105.6.2** Each contractor and surety involved shall assume all liability, financial or otherwise, in connection with the contract and shall indemnify and save harmless the State, the Commission, its agents, employees and assigns from any and all damages or claims that may arise because of inconvenience, delay or loss experienced, caused or contributed to by the contractor because of the presence and operations of other contractors working within the limits of the same project.

**105.6.3** The contractor shall schedule and conduct work and shall place and dispose of the material being used so as not to interfere with or cause unnecessary inconvenience or delay to the operations of other contractors within the limits of the same project. The contractor shall join work with that of the other contractors as required by the contracts or in a manner acceptable to the engineer and shall perform it in proper sequence with that of the other contractors. When necessary for proper prosecution of work, each contractor shall permit the other contractors access through overlapping construction areas and the use of any access or haul roads.

**105.7 Cooperation With Utilities.** All utility facilities and appurtenances within the project limits shall be located or relocated by the utility owner, unless otherwise specified. The locations of these utilities are as provided by the utility owners and may not be exact, particularly with regard to underground installations. Contractor work procedures are to account for the inaccuracy inherent in the representation of their locations.

**105.7.1** The contractor shall cooperate with utility owners and the engineer in the location and relocation of utility facilities to minimize effects upon contractor's work, interruption to utility service and duplication of work by the utility owners. Facilities or appurtenances that are to remain in place during construction shall be accounted for and protected by the contractor's work procedures. Utility location and relocation shall be made in accordance with 7 CSR Division 10, Chapter 3, Utility Location and Relocation.

**105.7.2** In the event utility services are interrupted as a result of breakage within the project limits, the contractor is to notify the appropriate utility authorities and cooperate with them until service has been restored. Work shall not commence around fire hydrants until provisions for continued service have been made and approved by the local fire authority.

**105.7.3** When the failure of the owners of utility facilities to cooperate and coordinate their work with that of the contractor results in actual delay to the contractor in the overall completion of the contractor's work, such delay will be considered in the count of working days or date specified for completion as contractor's sole compensation from the Commission, provided the contractor notified the engineer in writing of the delay at the time it occurs.

**105.7.4** The contractor shall use every precaution to prevent damage to all public and private utilities. Repairs to damaged utilities caused by negligent or wrongful acts or omissions on the part of the contractor shall be corrected at the contractor's expense. The damaged facilities shall be restored to a condition similar or equal to that existing before the damage occurred.

**105.7.5** Should there be located within the right of way any public or private utility facilities which are to remain in place and which will interfere with the contractor's proposed methods of operation, the contractor, in cooperation with the engineer, shall make all necessary arrangements with the owner for any temporary or permanent removal or relocation of such facilities desired for the contractor's convenience. Any cost involved shall be borne by the contractor.

**105.7.6** If utility facilities or appurtenances are found that are not noted in the contract documents, and could not be discovered in accordance with [Sec 102.5.5](#), the engineer will determine whether relocation of the utility is necessary to accommodate construction. If relocation is necessary, the engineer will proceed to make necessary arrangements with the utility owner and the contractor. Compensability and excusability will be determined under [Sec 104](#) and [108](#).

**105.8 Construction Stakes, Lines and Grades.** The contractor shall be responsible for giving the engineer reasonable notice of intent to perform work in a particular area of the project in order to afford the engineer sufficient time to set construction stakes establishing lines, slopes and profile grade. For roadway work, the engineer will set construction stakes establishing lines, slopes and profile grade and will furnish the contractor with all necessary information relating to these lines, slopes and grades. These stakes and marks will constitute the field control by and in accordance with which the contractor shall establish other necessary controls and perform the work. For structures, the engineer will stake and reference those centerlines and layout lines used as dimensional references on the plans and provide a benchmark at each structure location. The engineer will also provide and mark haunching information for the contractor's use in forming of all bridge decks. The contractor shall be responsible for providing all other lines, locations, alignment, grade elevations and any other necessary controls by use of engineering instruments or other tools or methods as required to build the structure.

**105.8.1** The contractor shall be responsible for the preservation of all stakes and marks, and if any of the construction stakes or marks are carelessly or willfully destroyed or disturbed by the contractor, the cost of replacing them may be charged against the contractor and deducted from the payment for the work.

**105.8.2** The contractor shall furnish and deliver at the contractor's expense the size, quality and quantity of stakes required by the engineer. If the stakes have not been delivered at the time and place required for use, the engineer may purchase the stakes and deduct the entire cost from any compensation due the contractor.

**105.8.3** Upon written request of the engineer, the contractor shall furnish such assistance as may be necessary for the purpose of making measurements and for driving stakes. The Commission will reimburse the contractor by regular payment estimate for assistance by contractor's employees which has been requested in writing by the engineer prior to its actual performance.

**105.9 Authority and Duties of Resident Engineer.** As the immediate representative of the Commission, the resident engineer has direct charge of the engineering details of each construction project and is delegated commensurate authority for the administration of the project. The resident engineer has the authority to reject defective material and to suspend and reject any work that is being improperly performed. The resident engineer will have no authority to modify the contract except as provided in the contract documents or expressly authorized by the Commission.

**105.10 Inspection of Work.** All material and each part or detail of the work shall be subject to inspection by the engineer. The engineer shall be allowed access to all parts of the work and shall be furnished with such information and assistance by the contractor as is required to make a complete and detailed inspection.

**105.10.1** If requested by the engineer, the contractor, at any time before acceptance of the work, shall remove or uncover such portions of the finished work as may be directed. After



examination, the contractor shall restore said portions of the work to the standards required by the specifications. Should the work thus exposed or examined prove acceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed will be paid for as determined under [Sec 109.3](#) or [109.4](#); but should the work so exposed or examined prove unacceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed, shall be at the contractor's expense. No work shall be done and no material shall be used without suitable inspection by the engineer.

**105.10.2** Any work done or material used without inspection by an authorized Commission representative may be ordered removed and replaced at the contractor's expense.

**105.10.3** If any unit of government or political subdivision pays all or a portion of the cost of the work covered by the contract, its respective representatives shall have the right to inspect the work.

**105.10.4** When any work is being done on, over or under railroad right of way or adjustments are being made to any public or privately-owned utility facility, the respective representatives shall have the right to inspect the work.

**105.10.5** Inspections authorized in [Secs 105.10.3](#) and [105.10.4](#) shall not make any of these agencies a party to the contract or affect the rights of the parties to the contract.

**105.10.6** Adequate provision for lighting meeting the prior approval of the engineer shall be provided by the contractor to permit satisfactory construction and inspection of all work done and material produced.

**105.10.7 Final Inspection.** Upon presumptive completion of the entire project, the engineer will make an inspection. If all construction contemplated by the contract has been completed to the engineer's satisfaction, that inspection will constitute the final inspection. The engineer will make the acceptance for maintenance upon completion of the final inspection. The engineer will notify the contractor in writing of acceptance for maintenance as of the date of the final inspection.

**105.10.7.1** Following the final inspection, the contractor, subcontractors and suppliers are relieved of any new or additional liability to third parties for personal injury, death or property damages which may be alleged to result from the design or construction of the work, unless additional work on the right of way is required by the engineer.

**105.10.7.2** Nothing in [Sec 105.10.7](#) shall be deemed to excuse the contractor of liability or responsibility for any personal injury, death or property damages which may have occurred prior to the final inspection of the work.

#### **105.11 Unauthorized and Defective Work.**

**105.11.1** Work done without lines and grades being given, or work done beyond the lines and grades shown on the plans or as given, except as otherwise provided in the contract, will be considered unauthorized and done at the expense of the contractor.

**105.11.2** All changes in the work or departures from the plans, except those due to reclassification of excavation material, will be considered unauthorized and at the expense of the contractor unless, before proceeding with the work, the contractor has a copy of an order record signed by the engineer, or a change order signed by all parties whose signatures are provided for, except the federal engineer. These forms will contain complete detailed

instructions regarding the proposed changes. Any departure from the instructions contained in such written order shall be considered unauthorized.

**105.11.3** The engineer may order unauthorized work removed and replaced at the contractor's expense.

**105.11.4** All construction and material which have been rejected or declared unsatisfactory shall be remedied or removed and replaced in an acceptable manner by the contractor at the contractor's expense. Upon failure of the contractor to remedy or remove and properly dispose of rejected material or work, or to replace them immediately after receiving written notice from the engineer, the engineer may employ labor to rectify the work, and the cost of rectification will be deducted from any payment due or which may become due the contractor.

#### **105.12 Load Restrictions.**

**105.12.1** The contractor's movement of equipment and vehicles over bridges and pavements within the limits of the project is subject to the load limit regulations for highways as prescribed by state statutes in effect when the movement occurs, and special permits from the Commission are required prior to the movement of any such equipment or vehicles with a gross weight (mass) in excess of the load limits permitted by statute. All costs of obtaining special permits shall be borne by the contractor. Width, length, height and weight (mass) limitations as prescribed by state statutes shall be adhered to by the contractor during the movement of equipment and vehicles over any part of the state highway system, to include project exceptions, and the contractor shall not move or operate any such equipment or vehicles which exceed any statutory limitation without special permits from the Commission. The contractor shall be responsible for the proper loading of equipment and vehicles in order to adhere to all applicable regulations. Material receipts issued by the engineer do not indicate compliance with any weight (mass) restriction regulations. The Missouri State Highway Patrol is responsible for enforcement of all Missouri commercial vehicle regulations. Material which cannot be transported by highway without exceeding a dimension or weight (mass) limitation as established by special permit rule 7 CSR 10-2.010 shall be shipped by means of other transportation to the destination or to the nearest shipping terminal. For short distances, permits will be considered for "super loads" as defined in the special permit rule. Issuance or denial of such permits is dependent upon the results of a roadway and structural analysis. All permits required for movement over highways other than those which are state owned or maintained shall be obtained by the contractor from the respective authority.

**105.12.1.1** Special permits will not be required for the movement of construction equipment over any part of a bridge or pavement which is constructed or rehabilitated in the contract.

**105.12.1.2** All movement will be subject to the same conditions and regulations established by the Commission for movements under special permits with the following additional requirements:

(a) Bridge deck must be protected by planking of uniform thickness not less than the full tread width of track.

(b) All concrete in the bridge must have achieved design strength and must not be less than 28 days old.

(c) Not more than one unit at a time may be moved over the structure.

(d) Equipment shall be centered on centerline of structure during the movement.

(e) Adequate provision shall be made to prevent marring of the pavement surface or the loss of surface texture.

(f) Portland cement concrete pavement must have achieved the specified age and strength required for opening to all traffic.

(g) Adequate provision shall be made to assure uniform load distribution at the edges of the pavement.

(h) All movements shall be made under the supervision of the resident engineer.

**105.12.1.3** Movement of equipment over bridges or pavement not constructed under the contract, but located within the limits of the contract, is subject to all requirements of this section and a special permit will be required.

**105.12.2** Track or crawler type equipment having a gross weight (mass) of 40,000 pounds (18.144 Mg) or less, evenly distributed over the treads, may be moved over bridges not posted for lesser loads or rigid type pavements without special permits. Such equipment having a gross weight (mass) in excess of 40,000 pounds (18.144 Mg), shall have a special permit before moving. Crawler type equipment having a gross weight (mass) in excess of 75,000 pounds (34.020 Mg) will not be permitted on bridges or rigid type pavements except in rare instances.

**105.12.3** Track or crawler type equipment which is subject to unequal distribution of weight (mass), such as cranes and paving mixers and which have a gross weight (mass) in excess of 18,000 pounds (8.165 Mg) but less than 40,000 pounds (18.144 Mg), may be operated upon bridges not posted for lesser loads and rigid type pavements, provided special precautions satisfactory to the engineer are taken to distribute the weight (mass) evenly over the treads. Such equipment in excess of 40,000 pounds (18.144 Mg) will require a special permit from the Commission.

**105.12.4** The contractor shall not move or operate any type of equipment of such weight (mass) or so loaded that it will cause damage to highway facilities either being constructed or in existence. Equipment and vehicles with steel lugs will not be permitted to operate directly on bridges or pavements at any time.

**105.12.5** When it is required that material from roadway or borrow excavation be hauled across existing pavement, the contractor may move the material across the pavement with equipment that results in overweight loading, provided the following requirements are met at the contractor's expense:

(a) The contractor and the engineer shall select the location or locations where the crossing of the existing pavement is to be made. The width of the crossing shall be clearly marked on the pavement by painted lines and the contractor's equipment will be required to operate within the limits of the marked crossing.

(b) The contractor shall obtain written permission, including description of location of the crossing, from the engineer prior to movements of overweight loading across the existing pavement.

(c) The existing pavement shall be kept open at all times for highway traffic except for short periods of time when individual pieces of equipment are crossing the pavement. The pavement shall be kept reasonably free from earth or other material during hauling operations

and shall be cleaned off and kept clean during periods when no hauling across the pavement is in progress.

(d) The pavement and shoulders within the crossing area shall be maintained by the contractor in a condition satisfactory to the engineer.

(e) The contractor shall provide signs and flaggers to direct traffic when hauling across the pavement.

(f) If any hauling across the pavement is done at night, the contractor shall also provide adequate lighting to illuminate the crossing.

(g) If the existing pavement at the crossing is to be used in place after the contract is completed, the contractor shall, upon completion of the hauling operations, remove the existing shoulders, pavement and base between the limits of the crossing and replace it with the same type, width and thickness of shoulders, pavement and base.

(h) The contractor shall construct and maintain all necessary bypasses or temporary connections required for the proper handling of traffic during the removal and replacement of the pavement in the crossing area.

**105.12.6** Nothing contained herein or in any special permit will relieve the contractor of liability for any damage caused to highway facilities from the movement or operation of equipment and vehicles over the highway system.

**105.13 Maintenance of the Work.** The contractor shall maintain the work during construction until accepted. This maintenance shall be prosecuted so that the roadway or structures are kept in satisfactory condition at all times.

**105.13.1** In the case of a contract for the placing of a course upon a course or subgrade previously constructed, the contractor shall maintain the previous course or subgrade during all construction operations.

**105.13.2** No direct payment will be made for maintenance before the work is accepted.

**105.13.3** After the fertilizing, seeding and mulching have been completed or the partial application specified in [Sec 805.3.2](#) has been made for an area of not less than one acre (0.5 ha) of work, and the slopes are completed from the top down as far as practicable, the contractor may request the engineer to inspect the completed area. If upon inspection the engineer finds such items to be satisfactory, the contractor will be notified in writing of the limits within which the fertilizing, seeding and mulching will be accepted. Thereafter, the contractor will be reimbursed for maintenance and for replacement of fertilizer, seed and mulch, if directed by the engineer as provided in [Sec 109.4](#), unless such maintenance or replacement is made necessary by damages attributable to actions or negligence of the contractor.

**105.13.4** After completion of the 21 day maintenance period for sod specified in [Sec 803.3.3](#), the contractor may request the engineer to inspect any completed area of sodding of not less than 1500 square yards (1250 m<sup>2</sup>) or of completed isolated areas which total 1500 square yards (1250 m<sup>2</sup>). If upon inspection the engineer finds the sodding to be satisfactory, the contractor will be notified in writing of the limits within which the sodding will be accepted. Thereafter, the contractor will be reimbursed for maintenance if directed by the engineer as provided in [Sec 109.4](#) and for replacement of sodding if directed by the engineer, at contract

unit prices, unless such maintenance or replacement is made necessary by damages attributable to actions or negligence of the contractor.

**105.14 Failure to Maintain Roadway or Structure.** If the contractor, at any time, fails to comply with the provisions of [Sec 105.13](#), the engineer will notify the contractor of such non-compliance. If the contractor fails to remedy unsatisfactory maintenance within 24 hours after receipt of such notice, the engineer may immediately proceed to maintain the project, and the entire cost of this maintenance will be deducted from monies due or to become due the contractor.

#### **105.15 Acceptance.**

**105.15.1 Partial Acceptance.** If at any time during the prosecution of the work the contractor completes any section of work one mile (1.5 km) or more in length, he may request the engineer to inspect that section. If the engineer finds upon inspection that the section has been completed in compliance with the contract, the engineer will accept that section as being completed and the contractor will be relieved of further responsibility for that section. Partial acceptance will also include identified work inspected and accepted under [Sec 104.7.5](#).

**105.15.1.1** If the contract contains seasonal items such as sodding or painting, or such items as might delay the final completion of the project, a partial acceptance of the completed portion may be made prior to completion of the entire project. If the engineer finds upon inspection that the completed work is in acceptable condition, the contractor will be notified in writing and after such notice has been given, the contractor will be relieved of the duty of maintaining and protecting that work to the extent provided in the notice.

**105.15.1.2** Nothing in the contract shall be construed to relieve the contractor of full responsibility for making good any non-latent defect in work or material found on any section of work prior to final acceptance of the entire project, to alter in any manner the method of payment prescribed in the contract or to constitute a waiver of any claim the Commission might have against the contractor on the entire project.

**105.15.2 Final Acceptance.** The engineer will make the final acceptance upon completion of the final inspection and acceptance for maintenance as defined in [Sec 105.10.7](#), receipt by the engineer of all project documentation required by the contract and verification by the engineer that all material incorporated into the work has been properly inspected.

**105.15.2.1** When required by the contract, project documentation shall consist of Form C-242 (Contractor's Affidavit Regarding Settlement of Claims), Final Change Order, DBE Participation List and Final Verification, Structural Steel Certification and FHWA-47 (Statement of Materials and Labor Used By Contractors on Highway Construction Involving Federal Funds).

**105.15.2.2** Final acceptance does not excuse the contractor's liability or responsibility to the Commission for any latent defects in the work or material incorporated into the work, or for claims relating to any work or material incorporated into the work.

#### **105.16 Claims for Adjustment.**

**105.16.1** If dissatisfied with the engineer's decision under [Sec 104.5](#) or [Sec 108.14](#), the contractor shall notify the engineer in writing of the intention to make a claim before beginning or resuming the work in question. If notification is not given, or the contractor does not afford the engineer proper access to documentation supporting actual costs, the contractor waives any claim for additional time or compensation. Notice by the contractor and the fact

that the engineer has kept account of the costs shall not be construed as substantiating the validity of the claim.

**105.16.2** Claims for additional time or compensation under [Sec 104.5](#) shall be filed within 60 days after completing the work in question. Claims for additional time or compensation under [Sec 108.14](#) shall be filed within 60 days after receipt of the engineer's determination. The procedures for filing and disposition of the claim shall be as described in [Sec 105.16.3](#) through [105.16.9](#).

**105.16.3** If the contractor has any claim against the Commission arising out of the provisions of the contract or the performance or non-performance thereunder, and is not within the scope of [Sec 105.16.2](#), the claim shall be filed within the earlier of:

(a) 60 days after the date of delivery into the United States mail of the check or draft for the final retained percentage or the date of receipt of funds transferred electronically or otherwise,

(b) 90 days after the date of final inspection under [Sec 105.15.2](#),

(c) 60 days after the date of termination of the contract under [Sec 108.12](#), or

(d) 60 days after the written declaration of default under this contract.

**105.16.4** If the Commission has a claim against the contractor which in any way arises out of the provisions of the contract or the performance or non-performance thereunder, the claim will be filed within 60 days of delivery into the United States mail of the check or draft for the final retained percentage, or the date of receipt of funds transferred electronically or otherwise, except for claims of a differing site condition or defects in work or material under [Sec 105.15.2.2](#).

**105.16.5** If the claim is against the Commission, the written claim shall be personally delivered or sent by certified mail to the office of the secretary of the Commission in Jefferson City, Missouri. If the claim is against the contractor, the written claim will be personally delivered or sent by certified mail to the contractor at the address shown under the signature on the contract. If the claim is against an assignee, the written claim will be personally delivered or sent by certified mail to the assignee at the address shown on the accepted notice of assignment. The party against whom a claim is filed shall file any written counter claims within 60 days after receipt of the claim.

**105.16.5.1** This provision shall not extend the claim filing time limits of the contractor or the Commission in the case of a differing site condition or a suspension of the work under [Sec 108.14](#).

**105.16.5.2** This provision will not limit the Commission's claim filing time for defects in work or material not discovered within 60 days of delivery of the final retention or other rights not discovered within 60 days of filing of any claim by the contractor.

**105.16.6** Claim submittals shall be in sufficient detail to enable the engineer to determine the basis for additional time or compensation. The following minimum information must accompany each claim submitted:

(a) Detailed factual statement of the claim providing all necessary dates, locations and items of work affected by the claim.



faith. The Affiant has the requisite knowledge of the Claim, and the facts and supporting data, to be able to make this Affidavit and accurately attest to the facts herein.

3. All documents, records, charts, schedules, computer programs and printouts, and other data of any nature or description, which are submitted in support of this Claim pursuant to [Sec 105.16.5](#) of the *Missouri Standard Specifications for Highway Construction* are accurate and complete in all respects, to the best knowledge and belief of the Affiant and the Claimant.

4. Under all applicable penalties of state or federal law for perjury, submitting a false affidavit or statement, fraud, stealing or other falsification, the Affiant hereby certifies that this Claim for extra compensation and time, if any, submitted herewith by the Claimant for work performed on this contract, is a true and accurate statement of the Claimant's actual costs incurred and time sought in performing the contract work, and is fully documented and supported under and pursuant to the contract described above between the Claimant and the Missouri Highways and Transportation Commission.

5. This Affidavit is given in compliance with [Sec 105.16](#) of the *Missouri Standard Specifications for Highway Construction*, which forms a part of that contract.

\_\_\_\_\_  
(Type or Print Name of the Claimant)

By: \_\_\_\_\_  
(Affiant's Legal Signature)

Subscribed and sworn to before me, a notary public, on this \_\_\_\_ day of \_\_\_\_\_, (year).

\_\_\_\_\_  
Notary Public

My commission expires: \_\_\_\_\_

**105.16.7.1** The person signing the claim and affidavit under oath must be the owner if the contractor is a sole proprietorship, must be a general partner if the contractor is a partnership, must be an authorized agent if the contractor is a limited liability company or joint venture or must be an authorized officer or member of the board if the contractor is a corporation.

**105.16.8 Review of Claims.** During the review of the claim, the contractor, subcontractors and suppliers shall cooperate with MoDOT and shall provide at a minimum, access to the following documents:

- (a) Daily time sheets and supervisor's daily reports.
- (b) Union agreements, if any.
- (c) Insurance, welfare and benefits records.
- (d) Payroll register.
- (e) Earnings records.



- (f) Payroll tax returns.
- (g) Material invoices, purchase orders, and all material and supply acquisition contracts.
- (h) Material cost distribution worksheets.
- (i) Equipment records (list of company equipment, rates, etc.).
- (j) Vendor rental agreements and contracts with subcontractors and suppliers.
- (k) Subcontractor payment records and invoices.
- (l) Canceled checks (payroll and vendors).
- (m) Job cost report.
- (n) Job payroll ledger.
- (o) General ledger, general journal (if used) and all subsidiary ledgers and journals together with all supporting documentation pertinent to entries made in these ledgers and journals.
- (p) Cash disbursements journal.
- (q) Financial statements for all years reflecting the operations on this project.
- (r) Income tax returns whether such records are maintained by the company involved, its accountant or others.
- (s) Depreciation records on all company equipment.
- (t) All other documents used to develop costs for the contractor's internal purposes in establishing the actual cost of owning and operating equipment.
- (u) All documents that reflect the contractor's actual profit and overhead during the time the project was being performed and for each of the five years prior to the commencement of this project.
- (v) All bid records related to the preparation of the contractor's bid including the final calculations on which the bid was based unless the documents are placed in escrow.
- (w) Worksheets used to prepare the claim, establishing the cost components for items of the claim including, but not limited to, labor, benefits and insurance, material, equipment, subcontractors and all documents that establish the time periods, individuals involved, the hours and the rates for the individuals, schedule analyses, all data input used or developed for computer analysis or generation of the claim.
- (x) Projected and actual work force and equipment schedules and plans.
- (y) Any internal budget for the project.

**105.16.9** On any claim for additional compensation for work on the project, whether claimed under the contract, for a differing site condition, as a change in the work, for breach of the contract, for a positive representation by which the contract was induced or otherwise, the following items shall never be allowable or claimed directly or indirectly:

(a) Attorney fees, consultant or claims preparation costs or costs related to litigation.

(b) Any item which would not be eligible for federal-aid participation under the provisions of 23 CFR 635.124, regardless of whether the project is one approved by the FHWA.

(c) Any item which would be an expressly unallowable cost under the provisions of 48 CFR Part 31, Subparts 31.1 and 31.2, or as it may be amended, superseded or replaced during the life of the contract.

**105.16.10** Any claim or item of any claim not included in the writings required to be filed in [Sec 105.16](#), or any claim included but not clearly defined and specifically set out, itemized and supported, or any notice or claim not filed within the time and in the manner provided in [Sec 105.16](#), shall be forever waived, and shall neither constitute the basis of nor be included in any legal action, counterclaim, defense, set-off, arbitration or other alternative dispute resolution procedure mutually agreed upon between the parties.

**105.16.10.1** The omission of any claim or item of a claim or the detail required by [Sec 105.16.6](#) may not be cured by information provided during review of the claim.

**105.16.10.2** MoDOT has established a written procedure for handling contractor claims which provides the process for resolution of all claims and the engineer's final decision. The completion of that process and the engineer's final decision shall be a condition precedent to any legal action, counterclaim, defense, set-off or arbitration concerning the matters claimed.

**105.16.11** MoDOT's review of a claim pursuant to [Sec 105.16.8](#) shall be in addition to the right or duty of MoDOT or Commission to conduct audits or other reviews of a claim or contractor's books of account or operations otherwise provided by federal or state laws or the rules of civil procedure.

**105.17 Venue.** Any action concerning any matter, thing or dispute arising out of or relating to the terms, performance, non-performance or otherwise of the agreement, shall be brought in the Circuit Court of Cole County, Missouri. The parties agree that the contract is entered into at Jefferson City, Missouri, and substantial elements of its performance will take place or be delivered at Jefferson City, Missouri, by reason of which the contractor consents to venue of any action by or against it in Cole County, Missouri. The contractor shall cause this provision to be incorporated in all of its agreements with, and to be binding upon, all subcontractors in the performance of this agreement.

## **SECTION 106**

### **CONTROL OF MATERIAL**

#### **106.1 Source of Supply and Quality Requirements.**

**106.1.1** All material needed in the work shall be furnished by the contractor unless otherwise stated in the contract. The contractor shall assume full responsibility for ordering material of the quality and quantity required. The contractor shall be responsible for the delivered costs of all material ordered.

**106.1.2** The material used on the work shall meet all quality requirements of the contract. They shall be obtained from sources of supply which meet the approval of the engineer. If it is found that a uniform product is not being furnished from a source of supply or if, for any reason, the product from any source at any time proves to be unsatisfactory, the contractor may be required to furnish approved material from other sources. The engineer has the right to reject the entire output of any source where it is impracticable to secure a continuous flow of uniformly satisfactory material.

**106.1.3** Any work incorporating material which have not had prior approval of the engineer shall be performed at the contractor's risk and may be considered as unacceptable and unauthorized and, if so considered, will not be paid for. If a change in source will affect the control or appearance of the work, the use of any one kind or class of material for a specific project from more than one source is prohibited, except by permission of the engineer. Such permission, if granted, will set forth the conditions under which the change may be made.

**106.1.4** Material is subject to inspection or test at any time during production or manufacture or at any subsequent time prior to or after incorporation into the work. The points of inspection will be determined by the engineer. Initial inspection, testing and approval or rejection will be made as early as practicable. The engineer may waive any of the requirements regarding determination of quality and accept material on certification or visual inspection if, in the engineer's judgment, the quantity involved is too small or its use not sufficiently important to warrant tests.

**106.1.5** To expedite the inspection and testing of material, the contractor shall notify the engineer of the proposed sources of material prior to delivery. At the option of the engineer, material may be approved at the source of supply before delivery is started.

#### **106.2 Local Material Sources.**

**106.2.1 Designated Sources.** The Commission may acquire and make available to the contractor the right to take material from sources designated on the plans or described in the contract together with the right to use designated property if so specified, for plant site, stockpiles and hauling roads. In general, the quality of material contained in such sources is considered to be acceptable, but the contractor shall determine the method of operation, equipment and work required to produce a material meeting the specifications from the source. Designation of a source for material is not a representation of the quantity of acceptable material obtainable or the method, equipment or work required to obtain material from the source. It shall be understood that it is not feasible to ascertain from samples the limits for an entire deposit, and that variations shall be considered as usual and are to be expected. The engineer may order procurement of material from any portion of a deposit and may reject portions of the deposit as unacceptable.

**106.2.2 Contractor Furnished Sources.** If sources of material are not designated on the plans or described in the contract, or if the contractor desires to use material from sources other than those designated, the contractor shall acquire the necessary rights to take material from the sources and shall pay all costs related thereto, including any which may result from an increase in length of haul. All costs of exploring, meeting environmental requirements and developing such other sources shall be borne by the contractor. The use of material from other than designated sources will not be permitted until representative samples taken by the contractor in the presence of the engineer have been approved and written authority is issued for the use thereof. If sources of material or material deposits are provided by the contractor, the engineer will test the samples and determine the suitability of the material. Where practicable, borrow areas, gravel pits and quarry sites shall be located so that they will not be plainly visible from the highway.

**106.2.3 Operation of Sources.** Whether sources of material are acquired and made available by the Commission or are furnished by the contractor, the areas shall be excavated or worked in such manner to avoid or minimize siltation of streams, lakes, ponds and reservoirs.

**106.2.4 Final Condition of Sources.** Unless otherwise permitted, pits and quarries shall be so excavated that water will not collect and stand therein. Sites from which material has been removed shall be left in such condition to avoid or minimize siltation of streams, lakes, ponds and reservoirs, and if plainly visible from the completed highway, shall be left in a neat and presentable condition upon completion of the work.

**106.3 Samples, Tests and Cited Specifications.** Samples for tests will be taken by the engineer and shipped to the laboratory in accordance with MoDOT's Materials Manual. There shall be no direct charge to the Commission for material taken as samples, either for field tests or for laboratory tests. If a specification of a recognized national standard agency (AASHTO, ASTM, AWS, AWWA, etc.) is designated, the material shall meet either the designated specification if a date is indicated or the latest revision thereof in effect at the time of bid opening. Tests of samples of material will be made by the engineer in accordance with the methods specified in the contract or in accordance with the latest methods in effect at the time of bid opening, as prescribed by the national standard agency. Such national standard specifications and methods of tests shall include those designated as tentative, interim or amended and officially approved and published by the sponsoring agency. If appropriate methods have not been so prescribed, tests shall be performed in a manner determined by the engineer.

**106.4 Plant Inspection.** The engineer may inspect material at the source. If plant inspection is undertaken the following conditions shall be met.

**106.4.1** The engineer shall have the cooperation and assistance of the contractor and the producer of the material.

**106.4.2** The engineer shall be permitted free access to all parts of the plant as required for adequate inspection of the plant equipment and selection of samples. Every reasonable facility shall be furnished for the procurement of samples, performance of the tests and for the protection of testing equipment and supplies when tests are made at the source of production.

**106.4.3** If bituminous shipments are considered by the engineer to be frequent enough to justify testing at the source, laboratory facilities and testing equipment meeting requirements of the prescribed methods shall be provided by the supplier. The space and equipment shall be adequate for the orderly and proper testing of material without interference to or by the refinery personnel.

**106.4.4** When requested, a Type I Field Laboratory, in accordance with [Sec 601](#), shall be furnished at the aggregate source. No direct payment will be made for providing the laboratory.

**106.4.5** The Commission will refuse to provide plant inspection at sources where adequate safety measures are not provided and maintained.

**106.4.6** The Commission reserves the right to inspect plant equipment and to retest all material prior to or after incorporation into the work and to reject all material which, when retested, do not meet the requirements of the specifications.

**106.5 Storage of Material.** The contractor shall be responsible for proper storage and handling of all material to ensure preservation of required quality. The engineer may direct that material be placed on wooden platforms or other hard, clean surfaces, or that they be protected from the weather. Material in storage shall be so arranged as to facilitate inspection.

**106.6 Handling Material.** All material shall be handled in such manner as to preserve the material's quality and fitness for the work. Aggregates shall be transported from the storage site to the work in tight vehicles constructed to prevent loss or segregation of material after loading and measuring.

**106.7 Unacceptable Material.** All material not conforming to the requirements of the specifications when initially inspected and tested, will be considered as defective and all such material, whether in place or not, will be rejected and, unless remedied, shall be removed from the site of the work. Any material having once been inspected and approved that is subsequently found to deviate from the specification requirements to a degree which, in the judgment of the engineer, renders it unsuitable for use will be rejected even though it has previously been approved. Defective material, including any material furnished by the Commission which has been damaged by the contractor after delivery, shall be replaced or reconditioned by the contractor and at the contractor's expense. Rejected material, which has been reconditioned or corrected so that it satisfactorily meets the specifications, shall not be used without the engineer's written approval.

**106.8 Material Furnished by the Commission.** If any material is to be furnished by the Commission, special provisions designating such material will be included in the contract documents. The cost of handling and placing such material after delivery to the contractor is included in the appropriate contract price. The contractor is responsible for all material upon receipt and deductions will be made from any monies due to the contractor to make good any shortages and deficiencies, from any cause whatsoever, for any damage which may occur after such delivery and for any demurrage charges.

**106.9 Buy America Requirement.** On all federal-aid projects, the contractor's attention is directed to Title 23, CFR, entitled "Buy America Requirements." Where steel or iron products are to be permanently incorporated in the contract work, steel or iron material must be manufactured in the USA except for "minor usage" as described herein. Furthermore, any coating process of the steel or iron shall be performed in the USA. The use of pig iron and processed, pelletized and reduced iron ore manufactured outside of the USA will be permitted in the domestic manufacturing process for steel or iron material.

**106.9.1** Any sources other than the USA as defined are to be considered as foreign. The required domestic manufacturing process includes formation of ingots and any subsequent process. Coatings include any which protect or add value to the product.

**106.9.2** "Minor usage" of foreign steel, iron or coating processes will be permitted, provided the cost of such products does not exceed 1/10 of one percent of the total contract cost or \$2,500.00, whichever is greater. If foreign steel, iron or coating processes are used, invoices to document the cost of the foreign portion, as delivered to the project, shall be provided and the engineer's written approval given prior to placing the material in any work.

**106.9.3** For each domestic permanent steel or iron item, the contractor shall furnish to the engineer for approval, a manufacturer's certification identifying the item and certifying that the manufacturing processes for the product occurred in the USA, including coating process if applicable. For foreign items a statement of the specific foreign manufacturing location(s) shall be provided.

**106.9.4** Upon completion of the project, the contractor shall certify to the engineer that all steel, iron and coating processes for steel or iron incorporated into the contract work were in accordance with this specification, except as noted. All exceptions and their costs shall be listed in the same document.

**106.9.5** When permitted in the contract, alternate bids may be submitted for foreign structural steel. The award of the contract when alternate bids are permitted will be based on the lowest total bid of the contract based on furnishing domestic structural steel or 125 percent of the lowest bid based on furnishing foreign structural steel. If foreign steel is awarded the contract, domestic structural steel may be used; however, payment will be at the contract unit price for foreign structural steel.

#### **106.10 Metric Implementation.**

**106.10.1 Equipment.** For projects let prior to and including September 2000, equipment such as scales, concrete and asphalt plants, and placement equipment may be scaled in, or measured in, metric or English units. For projects let after September 2000, all equipment used to produce material for metric projects shall be metric, and equipment for English projects may be metric. Equipment requiring calibration will be calibrated using its "as manufactured" units.

**106.10.2 Material.** All material shall be furnished quantified in the specified units of measure for dimensions and other physical aspects except as follows. English specified material may be metric if they are the equivalent or better, if it is done consistently, if other components or aspects are unaffected, and if approved by the engineer. There shall be no intended substitution of English quantified material for metric specifications. Any cost of re-design due to use of material with units of measure other than as specified by the contract shall be borne by the contractor.

**106.10.3 Project Documentation.** All project tickets, paperwork for measurement, certifications or reporting of material shall be in the unit measure specified in the contract, except that if English is specified, documentation may be furnished in metric units provided it is done consistently for the project and supplier.

## **SECTION 107**

### **LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC**

**107.1 Laws to be Observed.** The contractor shall know, observe and comply with all Federal and State laws, local laws, codes, ordinances, orders, decrees and regulations existing at the time of or enacted subsequent to the execution of the contract which in any manner affect the prosecution of the work, except as specified in the contract or as directed by the engineer. The contractor and surety shall indemnify and save harmless the State, the Commission, its agents, employees and assigns from any claim or liability arising from or based on the violation of any such law, code, ordinance, regulation, order or decree, except any local regulations, decrees, orders, codes or ordinances which the contract or the engineer has specifically directed that the contractor need not obey.

**107.1.1 Contract and Legal Inconsistency.** The engineer shall be notified immediately in writing if any discrepancy or inconsistency is discovered between the contract and any law, ordinance, regulation, order or decree.

**107.1.2 Local Building and Zoning Codes or Ordinances.** The projects of the Commission are not typically subject to local building or zoning codes or ordinances. Therefore, the contractor usually need not obtain a local building or zoning permit or variance for work done exclusively as the Commission's contractor on the Commission's project and the Commission's right of way. Other local codes or ordinances may not apply to the Commission, and thus to the contractor, as well. If any questions arise concerning whether the contractor must comply with a local code, ordinance, decree or order of any type, the contractor must advise the engineer of the problem immediately, for resolution by the engineer. This provision does not exempt the contractor from the requirement of thoroughly researching and determining, before submitting a bid on the contract and from complying with, all federal, state or local laws, regulations, codes, ordinances, decrees or orders which may apply to the contract work. The Commission is not responsible for the contractor's failure to be informed before bidding as to the federal, state and local laws, regulations, codes, ordinances, decrees or orders which may govern the contract work, or for the contractor's failure to determine before bidding which of these do not govern the contract work.

**107.1.3 Authentication of Certain Documents.** If plans, plats, detailed drawings or specifications for falsework, cofferdams or any other work are required to be submitted to the engineer, they shall be signed, sealed and stamped in accordance with the laws relating to architects and professional engineers (Chapter 327, RSMo).

**107.2 Permits, Licenses and Taxes.** Except as otherwise provided in the contract, the contractor shall procure all permits and licenses, shall pay all charges, fees and taxes, and shall give all notices necessary and incidental to the due and lawful prosecution of the work. No direct payment will be made for the cost of complying with this requirement.

**107.3 Patented or Copyrighted Devices, Material and Processes.** If the contractor is required or desires to use any design, device, material or process covered by letters, patent, copyright, service or trade mark, the contractor shall arrange and provide for such use by suitable agreement with the patentee or owner, and a copy of the agreement may be required by the Commission. The contractor and surety shall indemnify and save harmless the State, the Commission, its agents, employees and assigns from any suits, claims or damages arising

from the infringement upon or use of any patented, copyrighted or registered design, device, material, process or mark.

**107.4 Safety and Sanitary Provisions.** The contractor shall at all times take necessary precautions to protect the life and health of all persons employed on the project. The contractor shall be familiar with the latest accepted accident prevention methods and provide necessary safety devices and safeguards in accordance therewith. The Commission will refuse to provide inspection services at plants or work sites where adequate safety measures are not provided and maintained.

**107.4.1 Employee Accommodations.** The contractor shall provide and maintain in a neat and sanitary condition, such accommodations for the use of employees as may be necessary to comply with the requirements and regulations of any agency having jurisdiction over public health and sanitation. The contractor shall permit no public or private nuisance.

**107.4.2** All sanitary facilities and safety devices shall be furnished free to employees and no direct payment will be made for such facilities or devices.

**107.5 Public Convenience and Safety.** The contractor shall conduct the work in a manner that will ensure, as far as practicable, the least obstruction to traffic and shall provide for the convenience and safety of the general public and residents along and adjacent to the highway in an adequate and satisfactory manner.

**107.5.1 Obstructions Prohibited.** Fire hydrants on and adjacent to the highway shall be kept accessible to fire fighting apparatus at all times and no obstruction shall be placed within 10 feet (3 m) of any such hydrant. Footways, gutters, sewers, outlets, inlets and portions of highways adjoining the work under construction shall not be obstructed. Pavements over which hauling is performed shall be kept clean of spilled or tracked-on material at all times when in use by traffic.

**107.5.2 Material and Equipment.** During construction hours, equipment, material and vehicles utilized in construction of the project will only be allowed on shoulders, medians or pavements where the locations are closed to traffic, properly signed and occupied by ongoing construction operations unless otherwise approved by the engineer. Except in cases of emergency, construction equipment, material and vehicles will not be allowed on pavements or shoulders being utilized by traffic. If the contract specifies time periods the contractor will not be permitted to perform work, construction equipment or vehicles shall not enter or leave the construction area via the pavements handling traffic nor be operated on the pavements handling traffic within the construction area. During non-construction hours, construction equipment, material and vehicles will not be allowed within 30 feet (10 m) of the edge of the pavement or shoulders carrying traffic unless the equipment, material and vehicles are located in a properly protected area, an off-site storage area or as otherwise directed by the engineer.

**107.6 Bridges over Navigable Waters.** All work on navigable waters shall be so conducted that free navigation of the waterways will not be interfered with and that the existing navigable depths will not be impaired except as allowed by permit issued by the United States Coast Guard or the United States Army Corps of Engineers.

**107.7 Use of Explosives.** All blasting operations shall be conducted under the direct supervision of a blaster certified by the Missouri Limestone Producers Association. When explosives are used in the prosecution of the work, the contractor shall use the utmost care to prevent personal injury and property damage. The contractor shall be responsible for damage resulting from the use of explosives. The engineer has the authority to suspend any unsafe blasting operation. The contractor shall be familiar and comply with the rules and regulations



of any city, county, state or federal agency or any other agency which may have jurisdiction in the handling, loading, transporting, storage and use of explosives. All places used for explosives storage shall be marked clearly "DANGEROUS EXPLOSIVES".

**107.7.1** Before beginning work, the contractor shall furnish the engineer letters of approval for the proposed operation from the appropriate regulating agencies. The contractor shall notify in writing the appropriate fire protection jurisdiction of the intent to store, transport or use explosives and shall provide proof of notice to the engineer. The contractor shall provide the engineer with copies of all permits, blasting logs and seismic monitoring data.

**107.7.2** The contractor shall notify in advance each property owner, tenant and public utility company having structures or facilities close to the work of any intention to use explosives.

**107.7.3** Removal of any item or material of any nature by blasting shall be done in such a manner and at such time as to avoid damage affecting the integrity of the design and to avoid damage to any new or existing structure whether on Commission right of way or private property included in or adjacent to the work. Unless the contract documents or the engineer restricts such operation, it shall be the contractor's responsibility to determine a method of operation to ensure the desired results and the integrity of the completed work.

**107.7.4** The contractor and surety shall indemnify and save harmless the State, the Commission, its agents, employees and assigns from any claim related to the possession, transportation, storage or use of explosives.

#### **107.8 Preservation of Monuments and Artifacts.**

**107.8.1 Monuments.** The contractor shall not disturb or damage any land monument or property landmark until authorized by the engineer.

**107.8.2 Human and Archaeological Remains.** The contractor shall be responsible for reporting to the engineer the discovery of human remains, artifacts, fossils and other items of historical, archaeological or geological significance discovered within the right of way during construction. Such items shall remain in the Commission's custody and shall not be removed from the site unless directed by the engineer. The preservation and handling of such items shall be in conformity with [Sec 203.2.9](#).

**107.9 Forest and Park Protection.** Environmental and sanitary laws and regulations regarding the performance of work within or adjacent to state or national forests or parks must be obeyed. The contractor shall keep the project site in an orderly condition, dispose of all refuse, obtain permits for the construction and maintenance of all construction camps, stores, warehouses, residences, latrines, cesspools, septic tanks and other structures in accordance with the regulations and instructions issued by the forest or park supervisor. Forest fires shall be prevented and suppressed. The contractor shall require employees and subcontractors independently and at the request of forest officials to prevent and suppress forest fires and to notify a forest official of the location and extent of any fire.

**107.10 Environmental Protection.** The contractor shall comply with all federal, state and local laws and regulations controlling pollution of the environment. Pollution of streams, lakes, ponds and reservoirs with fuels, oils, bitumens, chemicals or other harmful material and pollution of the atmosphere from particulate and gaseous matter shall be avoided.

**107.10.1** Fording of streams is not permitted unless the plan for such operation meets the approval of the engineer and results in minimum siltation to the stream.

**107.10.2** When work areas or pits are located in or adjacent to streams, they shall be separated from the main stream by a dike or barrier to keep sediment from entering the stream. Care shall be taken during the construction and removal of such barriers to minimize siltation of the stream.

**107.10.3** Disposal of portland cement concrete residue and wash water, water from aggregate washing or other operations resulting in sediment shall be treated by filtration, settling basins or other means sufficient to reduce the sediment concentration to applicable limits established by the Department of Natural Resources.

**107.11 Responsibility for Claims for Damage or Injury.** The contractor and surety shall indemnify and save harmless the State, the Commission, its agents, employees and assigns from all claims or suits made or brought for personal injury, death or property damage, caused or contributed to be caused by:

(a) The negligence of the contractor, subcontractors, suppliers or their respective officers, agents or employees;

(b) The creation or maintenance of a dangerous condition of or on the Commission's property or right of way, which condition occurred at least in part due to the acts or omissions of the contractor, subcontractors, suppliers or their respective officers, agents or employees; or

(c) The failure of the contractor, subcontractors, suppliers or their respective officers, agents or employees, to perform the work in accordance with the plans and specifications.

**107.11.1** Neither the Commission nor the contractor, by execution of a contract, shall intend to or create a new or enlarge an existing cause of action in any third party. This provision shall not be interpreted to create any new liability which does not exist under the statutory limited waiver of sovereign immunity, or to waive or extinguish any defense which either party to this contract or their respective agents and employees may have to an action or suit by a third party.

**107.12 Contractor's Responsibility for Work.** Until work is accepted by the engineer, it shall be in the custody and under the charge and care of the contractor. The contractor shall restore or replace, at the contractor's expense, any lost or stolen Commission-owned material in the contractor's custody or control. Damages to any portion of the work before its completion and acceptance, caused by the action of the elements or from any other reason, shall be restored or replaced at the contractor's expense. Issuance of a payment estimate on any part of the work done will not be considered as final acceptance of any work completed up to that time. The Commission may, in its discretion, make such adjustment as it considers to be proper for damage to the work due to unforeseeable causes beyond the control of, and without fault or negligence on the part of the contractor.

**107.13 Liability Insurance Requirements.** The contractor shall procure and maintain at its own expense, until acceptance of the project by the engineer, liability insurance for all damages and losses imposed by law and assumed under the contract, of the kinds and in the amounts specified in [Secs 107.13.1](#) through [107.13.3](#). Before the contractor commences the work, the contractor shall require the insurance company or companies to furnish to the engineer evidence of such insurance showing compliance with these specifications. All insurance required in [Sec 107.13](#) shall be occurrence policies in a form acceptable to the engineer, and shall remain in force until all work required to be performed under the terms of the contract is satisfactorily completed as evidenced by its formal acceptance by the engineer.

Each policy or its declaration pages shall provide that the policy shall not be materially changed or canceled until the engineer has been given at least 30 days advance notice in writing. If any policy is canceled before the contract work is complete, a satisfactory replacement policy must be in force, with notice and evidence of insurance submitted to the engineer, prior to the effective date of cancellation of the former policy. All evidence of insurance and notices shall be submitted to: Division Engineer, Construction, MoDOT, 105 W. Capitol Avenue, P.O. Box 270, Jefferson City, Missouri 65102-0270. Upon request, the contractor shall promptly furnish the engineer with a complete copy of the policy. Failure to furnish evidence of proper insurance, or complete insurance policies when requested, will result in the temporary suspension of work as provided in [Sec 108.6](#), and may result in other claims or actions for breach of contract or otherwise, as may be recognized at law or in equity.

**107.13.1 Workers' Compensation Liability Insurance.** The contractor shall furnish evidence to the engineer that, with respect to the operations it performs, it carries workers' compensation insurance, or is qualified as self-insured, sufficient to comply with all its obligations under state laws relating to workers' compensation. The contractor shall also require each subcontractor on the project to furnish the same evidence to the engineer. This evidence shall be furnished to and approved by the engineer prior to the time the contractor or subcontractor commences work on the site of the project.

**107.13.2 Contractor's Liability Insurance with Additional Insured Parties.**

**107.13.2.1 Commercial General Liability Insurance.** The contractor shall obtain one or more occurrence-based policies of commercial general liability insurance (Form CG 00 01 or the equivalent) which provide coverage for the contract work. The minimum limits of liability for commercial general liability insurance shall be: \$1,000,000 each bodily injury or property damage occurrence, combined single limit, \$2,000,000 general aggregate with a per project endorsement and \$1,000,000 products/completed operations aggregate. Each such policy shall be endorsed so as to cover liability arising from blasting if applicable, other inherently dangerous activities and underground property damage. Each such policy shall be endorsed to include broad form general liability, contractual liability and completed operations coverage.

**107.13.2.2 Commercial Auto Liability Insurance.** The contractor shall obtain one or more occurrence-based policies of auto liability insurance which provide coverage for its owned, non-owned and hired vehicles of every type and description which are used in the contract work. The minimum limits of liability for such insurance shall be \$1,000,000 combined single limit.

**107.13.2.3 Additional Insureds.** Each such policy of commercial general liability insurance shall name the State of Missouri for the benefit of its State Legal Expense Fund, the Commission and its members, agents and employees, as additional insureds. Each commercial general liability insurance policy shall also contain a separation of insureds condition. The insurance afforded by the contractor shall be primary insurance.

**107.13.2.4 Subcontractor's Coverage.** If any part of the contract is subcontracted, each subcontractor, or the contractor on behalf of that subcontractor, shall obtain the same commercial general liability insurance and commercial automobile liability insurance coverage. The commercial general liability insurance shall name the same entities specified in [Sec 107.13.2.3](#) as additional insureds, and shall have the same separation of insureds conditions.

**107.13.3 Railroad Protective Liability Insurance.** In addition to other required liability insurance, the contractor shall provide railroad protective liability insurance for and in behalf of the railroad as outlined in provisions for each project. The insurance policy shall be

submitted to the engineer in original and duplicate for approval. No work will be permitted on the railroad right of way until such approval is granted.

**107.13.4 Insurance with Other Than Missouri Companies.** Any insurance policy required as specified above, if written by an insurance company organized in a state other than Missouri, shall be signed by an agent or broker licensed by the State of Missouri. In the case of policies written by companies organized in a state other than Missouri, the evidence of insurance submitted as authorized in the contract shall be signed by an agent or broker licensed by the State of Missouri. Nothing in this provision limits or waives the requirement that each insurance policy must be issued by a company authorized to issue such insurance in Missouri.

**107.14 Third Party Liability.** Neither the State of Missouri, the Commission nor the contractor, by execution of the contract including these specifications, intend to create a right of action in a third party beneficiary except as specifically set out in these specifications and the contract. It is not intended by any required contractual liability in the contract or in these specifications that any third party beneficiary have a cause of action arising out of the condition of the project when completed in accordance with the plans and accepted by the Commission.

**107.15 Personal Liability of Public Officials.** There shall be no personal liability upon the Chief Engineer, or any member, employee or agent of the Commission in carrying out any of the provisions of the contract or in exercising any power or authority granted to them, it being understood that in such matters they act as agents and representatives of the State, with official and public duty doctrine immunity. If any provision of the contract appears to impose a duty on such an individual, the duty remains exclusively that of the Commission and is not a personal duty or obligation of the individual.

**107.16 Contractors Which Are Not Resident In Missouri.** Any contractor which is not a permanent resident of or domiciled in Missouri shall provide the Commission with proof of compliance with the Missouri "nonresident employers" financial assurance laws at Sections 285.230 to 285.234, RSMo, before the contractor performs any work on a project.

**107.16.1** A nonresident contractor which is a "transient employer" as that term is defined in Section 285.230.1, RSMo, and 12 CSR 10-2.017(1)(A), shall file with the Commission a photocopy of its current transient employer's certificate of registration issued by the Missouri Department of Revenue, before performing any work on a project. A nonresident contractor which is not classified by the Missouri Department of Revenue as a "transient employer" because it has properly registered with the Missouri Department of Revenue and the Missouri Division of Employment Security, and has filed and paid its Missouri state income taxes for more than 24 consecutive months, shall file with the Commission a photocopy of its certificate of registration, issued by the Missouri Department of Revenue, that it is not a "transient employer" before performing any work on a project.

**107.16.2** The contractor shall require a nonresident subcontractor to file with the Commission a photocopy of its current transient employer's or alternate certificate of registration, as issued by the Missouri Department of Revenue, before that subcontractor performs any work on a project.

**107.16.3** Any nonresident contractor or subcontractor which fails to file the financial assurance forms with the Missouri Department of Revenue as required by Missouri law shall be prohibited from contracting for or performing labor on any project for a period of one year.

**107.16.4** No direct payment will be made for compliance with [Sec 107.16](#).

## **SECTION 108**

### **PROSECUTION AND PROGRESS**

#### **108.1 Subletting of Contract.**

**108.1.1** The contractor shall not sublet, sell, transfer, assign or otherwise dispose of the contract or contracts or any portion thereof, or of any right, title, or interest therein, without written consent of the engineer. Requests for permission to sublet, assign or otherwise dispose of any portion of the contract shall be in writing and accompanied by evidence that the organization which will perform the work is particularly experienced and equipped for such work. In case such consent is given, the contractor will be permitted to sublet a portion thereof, but the contractor's organization shall perform work amounting to not less than 50 percent of the total contract cost, except that any items designated in the contract as specialty items may be performed by subcontract and the contract value of any such specialty items so performed by subcontract may be deducted from the total contract cost before computing the amount of work required to be performed by the contractor. Consent to a subcontract shall not constitute the Commission's endorsement of the qualifications of the subcontractor.

**108.1.2** The value of the work sublet will be determined by multiplying the number of units of any contract item sublet by the unit price as set forth in the original contract or by a price agreed to by the engineer where no unit price is included in the contract for the work sublet. Approval of a subcontract is not approval of the agreed unit prices in the subcontract. The subcontractor shall perform the work described in the subcontract agreement. No subcontracts, or transfer of contract, shall in any case release the contractor's liability under the contract and bonds. Consent to a subcontract shall not create a direct contractual relationship between the subcontractor and the Commission.

**108.1.3** The contractor shall furnish to the Commission a complete copy of the signed subcontract, and all revisions upon request.

**108.2 Notice to Proceed.** The notice to proceed will stipulate the date the contractor is expected to begin work. The Commission will issue the notice to proceed by stipulating the date on the notice of award sent to all successful bidders, or on a separate form for this purpose. Prior to the stipulated date the contractor shall execute and file the prescribed number of copies of the contract and bond and shall furnish satisfactory evidence of having complied with insurance requirements.

#### **108.3 Prosecution of Work.**

**108.3.1** The contractor is expected to start work on the date stipulated by the notice to proceed. If all contract requirements have been met as specified in [Sec 108.2](#) the contractor may start work before the date stipulated by the notice to proceed provided the engineer is notified in writing at least three days in advance of the date on which the contractor expects to begin.

**108.3.2** The contractor shall continuously and diligently prosecute the work in such order and manner as will ensure its completion within the specified time, and shall be fully responsible for the prosecution and coordination of all work being performed under the contract.

**108.3.3** The work in progress shall receive the personal attention either of the contractor or of a competent and reliable superintendent who shall have full and final authority to act for the

contractor. If authority is delegated to a superintendent, the contractor shall notify the engineer in writing, stating the name of the person authorized to act as superintendent, and stating the name or names of the persons authorized to sign the various documents such as the weekly reports, change orders, force account statements, labor payrolls and any other documents that may be required during the progress of the work. If progress at any time is not adequate to meet the contractor's schedule and the contract completion time, the contractor shall take all steps necessary to complete the work in the time and manner specified in the contract.

**108.3.4** Prior to beginning any work in contracts involving a joint venture, the joint venturers shall appoint and maintain a single representative having full and final authority to act for the joint venture. The engineer shall be notified in writing of the name of this representative and of any replacements.

**108.4 Progress Schedules.** The contractor shall submit a progress schedule to the engineer for review at least seven days prior to the pre-construction conference. The progress schedule shall be used to establish the construction operations and to monitor the progress of the work although the engineer's determination of the then major operation or controlling item of work shall always prevail. The progress schedule shall be in the form specified in [Sec. 108.4.1](#), unless the contract contains a different requirement. The progress schedule shall be based on the number of working days, calendar days or other increments as set forth in the contract that the contractor expects to require in completing the project recognizing the capabilities of labor, equipment, arrangements for material, mobilization, shop drawing preparation and approvals, and other relevant items.

**108.4.1 Form and Contents of Progress Schedule.** The progress schedule shall contain an activities schedule chart and written narrative which shall break down into detail the time in working days, calendar days or completion date involved in performing all construction activities for the duration of the project, and shall be in a suitable scale as to indicate the percentage of work scheduled for completion at any time.

**108.4.1.1** The activities schedule chart shall contain:

(a) A bar chart chronologically sequenced and to time scale showing the order, identity and duration of all construction prosecution and preparation activities and the planned starting date of each activity.

(b) The durations represented by a bar shall note periods of planned non-work which exceed three consecutive calendar days and work planned during periods of normal seasonal shutdown or when certain activities are prevented by other provisions of the contract.

**108.4.1.2** The written narrative shall contain:

(a) A description of activities so that work can be measured by working days, calendar days or completion date schedule, and activity dependencies are identified.

(b) A description of each activity identifying the item and location of the work.

(c) A description of the activities schedule chart indicating planned work days per week, days allowed for weather, holidays, number of shifts per day, number of worker hours per shift and major items of equipment to be used to perform each activity.

**108.4.1.3** The activities schedule chart and written narrative shall also clearly outline the intended maintenance of traffic, work phasing provided by the contract and such other information as required by the contract or as deemed appropriate by the engineer.

**108.4.2 Preparation of Initial Schedule.** The contractor shall complete development of the initial activities schedule chart and written narrative and present a copy of each to the engineer at least seven days prior to the pre-construction conference.

**108.4.2.1** The construction time, as indicated by the activities schedule chart and written narrative, for the entire project or any milestone, shall not exceed the specified contract time. If any milestone date or contract completion date is exceeded in the schedule, time estimates on the activities schedule chart must be revised. Following a review of the initial activities schedule chart and written narrative by the engineer, the engineer and contractor shall meet for a joint review, correction and adjustment of the schedule if required.

**108.4.2.2** If necessary this process will be repeated. However, the schedule must be finalized by the contractor within seven days after request for correction and adjustment to the schedule.

**108.4.3 Intent and Cost of Progress Schedules.** The review by the engineer of any progress schedule does not constitute a determination that it is reasonable, that following it will result in timely completion, or that deviation will result in a delayed completion. The progress schedule and any updates provided are not a part of the contract. If the schedule reflects a completion date different than specified in the contract, that does not void the date or working days specified in the contract. If any schedule reflects a completion time earlier than that specified in the contract, the contractor specifically understands that no claim for additional contract time or compensation will lie against the Commission if the work is not completed by the earlier time shown on the schedule. It is the contractor's responsibility to determine the most feasible order of work consistent with the requirements of the contract.

**108.4.3.1** No direct payment will be made for furnishing progress schedules or revisions.

**108.4.3.2** If the contractor fails to comply with the requirement to supply an initial or any revised progress schedule or if the engineer determines the original or any revised progress schedule does not provide the information required, the engineer may withhold progress payments until a schedule complying with this section has been submitted and reviewed.

**108.4.4 Revised Progress Schedules.** The contractor shall provide a revised progress schedule, which shall then become the current progress schedule:

- (a) When requested by the engineer or required by the contract.
- (b) When departure from the existing progress schedule makes it apparent that the project will not be completed in the time provided in the contract.
- (c) When the contractor determines that the progress schedule requires revision for any reason.

**108.5 Labor, Methods and Equipment.** The contractor shall at all times employ sufficient labor, methods and equipment for prosecuting the work to full completion in the time and manner required by the contract.

**108.5.1** All workers shall have sufficient skill and experience to properly perform the work assigned to them. The engineer may demand the dismissal of any person employed by the contractor in, about or upon the work who engages in misconduct, is incompetent or negligent

in the due and proper performance of assigned duties, or who neglects or refuses to comply with any proper directions given. Such person shall not again be employed thereon without the written consent of the engineer. Should the contractor continue to employ or re-employ any such person, the engineer may suspend the work until the contractor complies with such orders.

**108.5.2** All equipment used on the work shall be of sufficient size and in such mechanical condition as to meet requirements of the work and to produce satisfactory work. The condition or use of equipment on any portion of the project shall not cause any damage to the roadway, adjacent property or other highways, or injury to any person.

**108.5.3** If the methods and equipment to be used by the contractor in accomplishing the construction are not prescribed in the contract, the contractor is free to use any methods or equipment that will accomplish the contract work in conformity with the requirements of the contract. The failure of the engineer to object to contractor's equipment or methods shall never constitute agreement that the equipment or methods used are appropriate.

**108.5.4** If the contract specifies that the construction be performed by the use of certain methods and equipment, such methods and equipment shall be used unless others are authorized by the engineer. If the contractor desires to use a method or type of equipment other than those specified in the contract, authority shall be requested from the engineer. The request shall be in writing, including a full description of the methods and equipment proposed to be used and an explanation of the reasons for desiring to make the change. If approval is given, the contractor shall be fully responsible for producing work in conformity with the contract. If the engineer determines that the work produced does not meet contract requirements after use of the substitute method or equipment, the contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the methods and equipment specified in the contract. The contractor shall remove the deficient work and replace it as specified in the contract, or take such other corrective action as the engineer may direct. Except as provided in [Sec 104.6](#), no change will be made in the basis of payment for the construction items involved nor in contract time as a result of approving any method or equipment change.

**108.6 Temporary Suspension of Work.** The engineer has authority to suspend any or all of the work as provided in [Sec 105.1.2](#) for such time as necessary. If it becomes necessary to stop work for an indefinite period, the contractor shall store all material in a manner that will protect the material from theft or damage, shall not unnecessarily obstruct traffic, shall take every precaution to prevent damage to or deterioration of work performed, shall provide suitable drainage of the roadway by opening ditches, shoulder drains, etc. and shall erect temporary structures where necessary. The contractor may suspend work for reasonable cause upon the written approval of the engineer. When all work except overseeding is completed during June, July, October or November, the engineer may approve the contractor's written request for a temporary suspension of work. The work day count or liquidated damages shall resume at the earliest date available for overseeding. During such a period in which work is suspended, liquidated damages shall not accrue unless such suspension is due to the contractor's failure to comply with the contract. If work has been suspended, the contractor shall notify the engineer in writing at least 48 hours before resuming operations.

**108.7 Contract Time for Completion of the Work.** The time for the completion of the work is specified by calendar days, calendar date or working days in the contract. Time is an essential element of the contract, and it is therefore important that the work be pursued vigorously to completion.



**108.7.1 Completion by Calendar Days or Calendar Date.** Any computation of time by calendar days or calendar date will be based on the seasonal importance of days on the basis of weighted time tables on file in the office of the Commission. If a change in the work is ordered by the engineer, the contractor will be allowed an extension of contract time based upon the weighted time tables and the ratio of the cost of such additional work to the contract price, unless it can be established that the additional work required more time than is indicated. In such cases, the actual time required, as determined by the engineer, may be allowed.

**108.7.1.1** If the notice to proceed is not issued and effective within 35 days after the award or the later date specified in the contract, due to any failure of the Commission, the contractor will be given an extension of contract time equal to the number of calendar days after the 35th day or the later date specified in the contract, until the notice to proceed is effective. Such a delay in the effective date of the notice to proceed shall be an excusable, noncompensable delay.

**108.7.1.2** The contractor will not be entitled to any extension of contract time because of unsuitable weather conditions unless authorized in writing by the engineer as an excusable, noncompensable delay under [Sec 108.14.1](#).

**108.7.2 Completion by Working Days.** If the time for the completion of the work is based upon working days, this time will be specified in the contract. A working day is defined as any day when, in the judgment of the engineer, soil and weather conditions would permit the major operation of the project for six hours or over unless other unavoidable conditions prevent the contractor's operations. If conditions require the contractor to stop work in less than six hours, the day will not be counted as a working day.

**108.7.2.1** December 15 to March 15, both dates inclusive, and Saturdays, Sundays, national and state holidays established by law will not be counted as working days.

**108.7.2.2** The count of working days will start on the date the contractor starts construction operations, or the effective date of the notice to proceed, whichever is earlier. The engineer will determine when a working day is to be charged. The engineer may make allowance for working days lost due to causes justifying their elimination from the count of working days. No allowance will be made for delay or suspension of the prosecution of the work due to fault of the contractor. Each week the engineer will give the contractor written notice of the number of working days charged for the preceding week. Any objection by the contractor to the number of working days so charged shall be made in writing within five days, setting forth the contractor's objections and specifying the reasons therefore, or those objections shall be forever waived and may not constitute the basis for an excusable or compensable delay.

**108.7.2.3** In case the final value of all work performed exceeds the original contract amount, an extension in the working days will be granted the contractor. The extension will be made by increasing the contract time by the ratio of the total final cost of all work performed under the contract to the total amount of the original contract. Incentive/disincentive, bonus or deduction adjustments will not be used in this computation. For a combination of projects awarded as a single contract, the extension will be made in a similar manner. If it can be established that the extra work required more time than indicated, the actual number of working days required, as determined by the engineer, may be allowed.

## **108.8 Liquidated Damages for Failure or Delay in Completing Work on Time.**

**108.8.1** If the contractor or, in case of default, the surety fails to complete the work within the time specified in the contract, or within such extra time as may be allowed in the preceding

sections, a deduction of an amount specified in the contract will be made for each day that the contract remains incomplete after the time allowed for completion. The amount specified in the contract is agreed upon, not as a penalty, but as liquidated damages for loss to the Commission and the public. This amount will be deducted from any money due the contractor. The contractor and surety shall be liable for all liquidated damages. Permitting the contractor to continue the work after the expiration of the specified time or any extension of time shall not constitute a waiver by the Commission of any contractual rights.

**108.8.1.1** A combination of projects awarded as a single contract will be considered as one unit for the determination of liquidated damages.

**108.8.1.2** Regardless of the method used to specify contract time for completion of the work, liquidated damages will not be charged as follows:

(a) From December 15 through March 15, both dates inclusive.

(b) For Saturdays, Sundays, national and state holidays established by law.

(c) During any 21-day period of sod maintenance as specified in [Sec 803.3.3](#), if such maintenance is the only work remaining and the contractor can perform the maintenance without inconveniencing the traveling public.

(d) During the final fifteen consecutive day test period for a signal system, as specified in [Sec 902.5.9](#), provided all other work has been completed.

**108.8.2** The Commission will not be required to file a claim or counterclaim under [Secs 105.16.3](#), [105.16.4](#) or any other provision, to assess or retain liquidated damages.

**108.8.3** The contractor and surety shall be liable for liquidated damages chargeable under the contract when the work is completed after default of the contract unless the delay is caused by the Commission. A delay in the work or the final completion of the project caused by the Commission shall not void the provisions of the contract as to liquidated damages and will be considered an excusable, noncompensable delay.

**108.9** If the engineer invokes the option under [Sec 901](#), [902](#) or [903](#) to have MoDOT personnel or a third party correct a lighting, signal or sign lighting-malfunction, the contractor will be charged for the service. If MoDOT personnel make the correction, the charge will be computed as 2.5 times the cost for all replacement parts, equipment rental, salaries and fringe benefits. If a third party makes the correction the contractor will be charged 1.2 times the charges billed the Commission by the third party. However, in no case will the charge be less than \$100.

**108.10 Default of Contract.** After notice and an opportunity to remedy, the engineer may declare the contractor in default, if the contractor:

(a) Fails to begin the work under the contract within the time specified to begin work.

(b) Fails to perform the work with sufficient resources to assure the timely completion of the work.

(c) Fails to perform the work in accordance with the contract requirements, or neglects or refuses to remove and replace rejected material or unacceptable work.

(d) Discontinues the prosecution of the work.

(e) Fails to resume work that has been discontinued within a reasonable time after notice to do so.

(f) Becomes insolvent, is declared bankrupt or commits any act of bankruptcy or insolvency, allows any final judgment to remain unsatisfied or makes an assignment for the benefit of creditors.

(g) Fails to comply with contract requirements regarding prevailing wage payments, DBE or EEO requirements.

(h) Is a party to fraud.

**108.10.1** The engineer will give notice in writing to the contractor and surety of the condition described in [Sec 108.10](#), and advise them of the actions required for remedy. If the contractor does not proceed to remedy the condition within ten calendar days of receipt of this notice, the engineer may declare the contractor in default. The declaration of default will be made in writing to the contractor and the surety.

**108.10.2** If within ten calendar days after receipt of the declaration of default, the surety does not proceed to assume the contract for completion under the direction of the engineer, the Commission has full power and authority, without impairing the obligation of the contract or the bond:

(a) To take over the completion of the work.

(b) To appropriate or use any or all project material and equipment that is suitable and acceptable.

(c) To enter into agreements with others.

(d) To use such other methods as in its judgment may be required for the completion of the contract in an acceptable manner.

**108.10.3 Liability for Costs.** The contractor and surety shall be liable for all costs and expenses incurred in completing the work, and also for all liquidated damages in conformity with the contract. The contractor and surety are obligated to comply with all change orders and directives of the engineer to the same extent, and for the same compensation (if any), as the contractor would have been in the absence of default. In case the sum of such liquidated damages and the expense so incurred is less than the sum which would have been payable under the contract if it had been completed by the contractor, the contractor or surety shall be entitled to receive the difference. If the sum of such expense and such liquidated damages exceeds the sum which would have been payable under the contract, the contractor and surety shall be liable and shall pay the amount of such excess. This provision shall apply, regardless of whether the surety or the Commission completes the contract work. The contractor and surety shall solely be liable for the costs and expenses of a completing contractor, laborers and suppliers with which either has contracted.

**108.10.4** If it is determined after termination of the contractor's right to proceed that the contractor was not in default, the rights and obligations of the parties will be the same as if the termination had been issued for the convenience of the Commission under [Sec 108.11](#). Sums to which a contractor may be entitled as a result of the contract termination will be limited to amounts determined under [Sec 108.11](#).

**108.10.5 Sureties' Continued Acceptability.** A surety failing to proceed within ten days after the written declaration of default by the engineer under Sec 108.10 may be required to show cause to the Commission why it should continue to be accepted for future bonds.

**108.11 Termination of Contract for Convenience of the Commission.** The Commission may terminate the entire contract or any portion thereof, if the engineer determines that a termination is in the Commission's interest. The engineer will deliver to the contractor and surety a notice of termination specifying the extent of termination and the effective date.

**108.11.1 Submittals and Procedures.** After receipt of a notice of termination, the contractor shall immediately proceed with the following obligations:

- (a) Stop work as specified in the notice.
- (b) Place no further subcontracts or orders for material, supplies, services or facilities, except as necessary to complete the portion of the contract that has not been terminated.
- (c) Terminate all subcontracts to the extent they relate to the work terminated.
- (d) Settle with subcontractors and suppliers all outstanding liabilities arising from the termination.
- (e) Transfer title and deliver to the Commission, work in progress, completed work, supplies and other material produced or acquired for the work terminated, and completed or partially completed plans, drawings, information and other property that, if the contract had been completed, would be required to be furnished to the Commission.
- (f) Complete performance of the work not terminated.
- (g) Take any action that the engineer directs to protect and preserve contract-related property that is in the possession of the contractor in which the Commission has or may acquire an interest.

**108.11.2 Settlement Provisions.** When the Commission orders termination of all or a part of the contract effective on a certain date, completed items of work as of that date will be paid for at the contract price. Payment for partially completed work will be made either at agreed prices or under the provisions below. When items are eliminated in their entirety by such termination, the contractor will be paid for actual work done and actual costs incurred before notification, including mobilization of equipment or material.

**108.11.2.1 Additional Costs.** Within 60 days of the effective termination date, the contractor shall submit any request for additional damages or costs not covered in Sec 108.11 or elsewhere in the contract. Such request may include only such cost items as: mobilization, overhead expenses proven to be attributable to the project or the part terminated and not paid for under work not terminated, subcontractor costs not otherwise paid for, actual idle equipment and idle labor cost only for any time the work is stopped in advance of termination date, guaranteed payments for private land usage as part of the original contract, and any other actual cost for which the contractor feels reimbursement should be made.

**108.11.2.1.1** Anticipated profits, including anticipated earnings on usage of owned equipment, and impact, delay or other direct or indirect costs resulting from this termination which are not expressly authorized, will not be compensable as part of any settlement.

**108.11.2.1.2** The contractor and the engineer may agree upon the whole or any part of the amount to be paid because of the termination. The amount may include a reasonable allowance for profit on work done. The agreed amount may not exceed the total contract price as reduced by the amount of payments previously made and the contract price of work not terminated. The contract will be amended and the contractor paid the agreed amount.

**108.11.2.2 Additional Cost Review.** If the contractor and the engineer fail to agree on the whole amount to be paid the contractor because of the termination of work, the Commission will pay the amounts determined as follows, but without duplication of any amounts agreed upon in [Sec 108.11.2](#):

(a) For contract work performed before the effective date of termination, the total (without duplication of any items) of:

(1) The actual cost of work performed.

(2) The cost of settling and paying termination settlements under terminated subcontracts that are properly chargeable to the terminated portion of the contract if not included in [Sec 108.11.2](#).

(3) A sum for profit on the actual cost of work performed as determined by the engineer to be fair and reasonable. The engineer will allow no profit under this section if the contractor's costs incurred on work performed exceed the contract prices paid.

(b) The reasonable costs to settle the work terminated, including:

(1) Internal accounting and clerical expenses reasonably necessary for the preparation of termination settlement proposals and support data, including expenses for termination and settlement of subcontracts.

(2) Storage, transportation and other costs incurred, reasonably necessary for the preservation, protection or disposition of the termination inventory.

(c) For normal spoilage and to the extent that the engineer expressly accepts the risk of loss. The engineer will exclude the fair value of property that is destroyed, lost, stolen or damaged so as to become undeliverable to the Commission or to the buyer.

**108.11.2.2.1** In arriving at the amount due the contractor under this clause, there will be deducted:

(a) All advanced payments for mobilization, services or facilities, or other payments to the contractor under the terminated portion of the contract.

(b) Any claim that the Commission has against the contractor under the contract.

(c) The agreed price for or the proceeds from the sale of material, supplies or other items acquired and sold by the contractor, and not recovered by or credited to the Commission.

(d) Any costs saved as a result of the termination.

**108.11.2.2.2** If the termination is partial, the contractor may file a proposal with the engineer for an equitable adjustment of the price(s) of the continued portion of the contract. The

engineer will make any equitable adjustment agreed upon. Any proposal for an equitable adjustment under this clause shall be requested within 60 days from the effective date of termination unless extended in writing by the engineer.

**108.11.2.2.3** The contractor shall maintain and make available all project cost records to the engineer for audit to the extent necessary to determine the validity and amount for each item requested. This includes but is not limited to all items described in [Sec 105.16.8](#). These records and documents shall be made available to the engineer at the contractor's office, at all reasonable times, without any direct charge. If approved by the engineer, photographs, microphotographs or other authentic reproductions may be maintained instead of original records and documents.

**108.11.3 Effect of Termination.** Termination of the contract or portion thereof shall not relieve the contractor of contractual responsibilities for the work completed, nor shall it relieve the surety of its obligation for and concerning that part of the contract not terminated or any just claim arising out of the work performed.

**108.12 Notice to Contractor and Surety.** Notice to the contractor, in case of default or termination of the contract, shall be deemed to be served when delivered to the person in charge of any office used by the contractor, the contractor's representative at or near the work or by certified mail addressed to the contractor's last known place of business. Notice to the surety shall be deemed served when mailed to the surety's address as shown in the contract by certified mail.

**108.13 Termination of Contract for Misconduct.** For the purposes of the following provision, "state" includes the State of Missouri and any other state, commonwealth or territory of the United States. The Commission may declare the contractor to be in default on the contract at any time after the contract is awarded and prior to final acceptance of the project, for any one or more of the acts set forth below, if it occurred during the life of the project or within the seven year period immediately preceding the date the contract was awarded, on any Commission or other federal, state or local government or private contract:

(a) Receiving or giving any currency or item of value in order to influence the competitive bidding process or the award of a competitively-bid contract; bid-rigging, collusion or any similar act or communication with any person or firm in restraint of competitive bidding on a contract; or to obtain or grant an advantage in obtaining the award of such a contract.

(b) Fraud, dishonesty or a material misrepresentation or omission of fact in any request for proposal or bid submitted to a private firm or governmental agency, or in any contract documents submitted to such a firm or agency.

(c) Making or receiving kickbacks or payments of currency or any item of value in order to obtain or retain any contract or payment thereunder, or in return for an agreement to make or for the making of any false statements or material misrepresentations or omissions of fact to any federal, state or local governmental agency or private firm relevant to contract compliance.

(d) Suspension, debarment or other disqualification of the contractor, or determination that the contractor is not a responsible bidder for public contracting purposes, by any federal, state or local governmental agency, regardless of whether the sanction is still in effect at the time of the bid or contract award by the Commission.

(e) Conviction or adjudication of guilt in any criminal proceeding in a federal or state court, regardless of whether sentence was suspended or executed, for any act an element of which is fraud, dishonesty or moral turpitude, which conduct is relevant to a determination of the responsibility of the contractor.

(f) Commission of any act or failure to act, such that the contractor is subject to the determination that it is not a responsible bidder under the contract or under applicable Missouri or federal law.

**108.13.1** The acts, omissions and liabilities of persons or firms affiliated with the contractor or of persons which are principals of the contractor, are those of the contractor, unless the circumstances clearly negate that conclusion. Persons or firms are "affiliates" of each other if, directly or indirectly, either one controls or has the power to control the other or a third person controls or has the power to control both. Examples of control include, but are not limited to: interlocking management or ownership, identity of interests among family members, shared facilities and equipment, common use of employees on projects or a new business entity organized following the determination of ineligibility or non-responsibility of a person or firm which has the same or similar management, ownership or principal employees as the ineligible person. A "principal" is an officer, director, owner, partner or other natural person within a firm with primary management, supervisory or contracting responsibilities.

**108.13.2** The Commission will not declare the contractor to be in default of the contract pursuant to this section if the contractor made a full and complete disclosure of the acts and circumstances described in [Sec 108.13](#) to the Commission in the bid or in writings submitted with the bid and the Commission did not determine the contractor to be non-responsible prior to making the award of the contract. The Commission is not precluded from declaring the contractor in default under this section if the information provided by the contractor did not constitute a full and complete disclosure of all facts and circumstances pertinent to the issue of the responsibility and integrity of the contractor.

**108.13.3** The Commission, upon a finding of default pursuant to this section, may terminate the contract immediately or at the occurrence of some specific date or event in the future, prior to project completion, upon delivery of a written notice to the contractor by actual service or by certified mail (return receipt requested), sent to the address of record of the contractor. Effective with the contract termination date, the contractor shall discontinue further work on the project and shall instruct subcontractors and suppliers to do the same, other than to remove promptly their personnel, equipment and supplies from the project site. The contractor shall be paid for all completed work to that date at the contract price. At the option of the engineer, the Commission may assume the possession and cost of any specially-fabricated material or supplies for the project which have been ordered prior to notice of termination but have not been installed on the date of termination. The contractor and surety shall be liable to the Commission for all costs and expenses incurred by the Commission in completing the project (including but not limited to the Commission's costs to redraft and rebid the project), which costs and expenses exceed the total of the contractor's bid price plus additional expenses allowed by the engineer during the contractor's work on the project, less the amount paid the contractor by the Commission. The Commission shall not be liable for damages for breach of contract or in any other action or respect for declaring a default if one exists under this section and for terminating the contract prior to completion by the contractor.

**108.13.4** The Commission may only exercise its right to declare a default of and terminate the contract under this section when it determines that the act of default described in this provision made the contractor non-responsible or ineligible for the award of this or other current or future Commission contracts. The satisfactory prosecution and progress toward project

completion by the contractor is no justification or defense to a Commission declaration of default on and termination of the contract under this section.

**108.13.5** The contractor shall file any claim it has against the Commission within 60 days after the effective date of termination, pursuant to the procedures of [Sec 105.16](#). The Commission will file any claim it has against the contractor or surety within 60 days of the date of final acceptance of the project, whether or not it is renumbered or redesigned, and whether completed by the surety, by a successor contractor retained by the Commission, or by the Commission itself. Any Commission claim will be filed pursuant to the procedures of [Sec 105.16](#).

**108.14 Determination of Compensation and Contract Time Extension for Excusable, Noncompensable and Compensable Delays.** An extension of the contract time may be granted under the following conditions provided documentation has been given to the engineer under [Sec 108.14.3](#) through [108.14.5](#). Strict adherence to the provisions of this section is a condition precedent to the contractor's entitlement to an extension of contract time or compensation because of project delays.

**108.14.1 Excusable or Noncompensable Delay.** Contract time allowed for the performance of the work may be extended for delays caused by acts of God, acts of the public enemy, fires, floods, earthquakes, epidemics, quarantine restrictions, strikes, freight embargoes, unusually severe weather or other delays not caused by the contractor's fault or negligence.

**108.14.2 Compensable Delay.** Contract time allowed for performance of the work may be extended for delays caused by the Commission. The contractor may be granted an extension of time and additional compensation only as provided by [Sec 109.11](#).

**108.14.3 Notification of Delay.** Within seven days of the occurrence of a delay to the prosecution of any phase of the work, the contractor shall notify the engineer in writing of such a delay and indicate that a request for delay consideration will be filed. Delay costs incurred prior to notifying the engineer that operations have been delayed are noncompensable.

**108.14.4 Procedures Following a Delay.** The contractor shall keep daily records of all non-salaried labor, material costs and equipment expenses for all operations that are affected by the delay.

**108.14.4.1** The contractor shall maintain a daily record of each operation affected by the delay and the station location of the operations affected. Daily records of the operations and stations will also be maintained by the engineer. Each Monday, the contractor shall compare the previous week's daily records with the records kept by the engineer. The contractor shall also prepare and submit written reports to the engineer each Monday containing the following information:

- (a) Number of days behind schedule due to the delay.
- (b) A summary of all operations that have been delayed or will be delayed.
- (c) In the case of a claimed compensable delay, the contractor shall explain how the Commission's act or omission delayed each operation and estimate the amount of time required to complete the project.
- (d) Itemize all extra costs incurred, including:



(1) How the extra costs relate to the delay and how they are being calculated and measured.

(2) The identification of all non-salaried project employees for whom costs are being compiled.

(3) A summary of time charges for equipment, identified by manufacturer's year and model and the contractor's number, for which costs are being compiled.

**108.14.4.2** The contractor shall provide written notice to the engineer within seven days of the results of the comparison of the detailed reports performed each Monday and define any disagreements between specific records.

**108.14.4.3** Failure to meet to review the engineer's records or to report disagreements between the records will be considered conclusive evidence that the engineer's records are accurate.

**108.14.5 Procedures Following Completion of Work Allegedly Delayed.** Within the earlier of 15 days of completion of any phase of work allegedly delayed, or of project completion, the contractor shall submit a report to the engineer containing the following information:

(a) A description of the operations that were delayed and the documentation and explanation of the reason for the delay, including all reports prepared by or for the contractor.

(b) An as-built chart or other graphic depiction of how the operations were delayed based on the contractor's most recent progress schedule prior to the delay event.

(c) An item by item measurement and explanation of extra costs requested for reimbursement due to the delay.

**108.14.5.1** All costs shown in the report submitted to the engineer must be directly caused by the delay event and reflect the actual costs incurred as shown on the contractor's project cost records kept in the ordinary course of business.

**108.14.5.2** The engineer will review the contractor's submission and any reports prepared for the engineer. A written decision will be provided to the contractor within 60 days of the receipt of the contractor's submission. This time may be extended if the engineer requires additional information.

**108.14.5.3** In the case of compensable delays, if the engineer determines that the Commission is responsible for delays to the contractor's operations, the engineer's written decision will reflect the nature and extent of any resulting equitable adjustment to the contract as provided in [Sec 109.4](#) and [109.10](#).

#### **108.15 Suspension of Work Ordered by the Engineer.**

**108.15.1** If the performance of all or any portion of the work is suspended or delayed by the engineer for an unreasonable period of time (not originally anticipated, customary or inherent to the construction industry) and the contractor believes that additional compensation or contract time is due as a result of such suspension or delay, the contractor shall submit to the engineer in writing a request for adjustment within seven days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment. The

procedures of [Secs 108.14.4](#) and [108.14.5](#) shall apply to requests for additional compensation or time claimed by the contractor as a result of a suspension of work ordered by the engineer under this section.

**108.15.2** Upon receipt, the engineer will evaluate the contractor's request. If the engineer agrees that the cost or time required for the performance of the contract has increased as a result of such suspension and the suspension was caused by conditions beyond the control of and not the fault of the contractor, suppliers or subcontractors, and not caused by weather, the engineer will make an adjustment (excluding profit) and modify the contract in writing accordingly. The engineer will notify the contractor of the engineer's determination whether or not an adjustment of the contract is warranted.

**108.15.3** No contract adjustment will be allowed unless the contractor has submitted the request for adjustment within the time prescribed.

**108.15.4** No contract adjustment will be allowed under this clause to the extent that performance would have been suspended or delayed by any other cause, or an adjustment is provided for or excluded under any other term or condition of the contract.

## SECTION 109

### MEASUREMENT AND PAYMENT

**109.1 Measurement of Quantities.** All work completed under the contract will be measured by the engineer according to United States standard measure or will be paid for on contract quantity basis as set out elsewhere in these specifications. When the quantity of any item that is to be paid for on a contract quantity basis is found to include errors, or when an authorized revision of the plan is made, the quantity will be corrected before making final payment. The method of measurement and computations to be used in determination of quantities of material furnished and of work performed under the contract will be those methods generally recognized as conforming to good engineering practice.

#### **109.2 Scope of Payment.**

**109.2.1** The contractor shall receive and accept compensation provided for in the contract as full payment for furnishing all material and for performing all work under the contract in a complete and acceptable manner and for all risk, loss, damage or expense of whatever character arising out of the nature of the work or the prosecution thereof subject to [Sec 109.8](#).

**109.2.2** The payment of any current or final estimate or the acceptance of any portion of the work as provided in the specifications shall not affect the obligations of the contractor to submit for final acceptance a completed improvement in accordance with the contract.

**109.3 Compensation for Altered Quantities.** When the accepted quantities of work vary from the quantities in the contract, the contractor shall accept payment at the original contract unit prices for the accepted quantities of work done. No allowance will be made for any increased cost except as provided in [Secs 104.2, 104.3 and 108.11](#).

**109.4 Differing Site Conditions and Changes in the Work.** Differing site conditions and changes in the work performed in accordance with [Sec 104.2](#) and [104.3](#) by the contractor and any subcontractor will be paid for using the following methods, in order of precedence.

**109.4.1 Contract Unit Prices.** Where contract unit prices exist, they shall always be applied without deviation unless the effect of a differing site condition or a significant change in the character of the work requires an equitable adjustment to a contract unit price under the terms of this contract. Equitable adjustments shall exclude any anticipated profits.

**109.4.2 Unit Prices or Lump Sum Amount Agreed Upon in the Change Order Authorizing the Work.** Where contract unit prices do not exist for the work to be done, the parties may agree to such unit prices or a lump sum price for that work. Where an equitable adjustment to a unit price is required, the parties may agree to the adjustment to be made to the contract unit price, excluding any anticipated profits. Prior to agreeing upon such unit or lump sum prices, the engineer may demand from the contractor any information which the engineer is authorized to require under [Secs 104.4 and 104.5.1](#).

**109.4.3 Equitable Adjustment.** In all other cases, except work ordered to be performed under force account, the engineer will make an equitable adjustment to or determination of the affected contract prices for the work, based upon the contractor's actual costs to perform the work. This determination will be consistent with the contractor's other proven costs to perform the contract work, as shown in the contractor's bid computations and project cost records, produced and kept in the ordinary course of business. Prior to making the equitable

adjustment, the engineer may demand from the contractor any information relevant to that determination including the information authorized under [Secs 104.4](#) and [104.5.1](#).

**109.4.4 Force Account.** Force account as computed under [Sec 109.5](#) applies only when expressly directed in writing by the engineer and in no other instance for any determination of additional compensation for any work performed on the project, whether claimed under the contract, for breach of the contract, for representations by which the contract was induced or upon any other basis.

#### **109.5 Force Account.**

**109.5.1 Labor.** For all lead workers and laborers the contractor will receive the rate of wage paid for each hour that said lead workers and laborers are engaged in the force account work.

**109.5.1.1** The contractor will receive the actual costs paid to, or on behalf of, employees for subsistence and travel allowances, health and welfare benefits, pension fund benefits or other benefits, if such amounts are required by the collective bargaining agreement or employment contract applicable to the classes of labor employed on the work.

**109.5.1.2** An amount equal to 20 percent (five percent profit and 15 percent overhead) of the sum of the above items will also be paid the contractor.

**109.5.2 Insurance and Tax.** For property damage, liability and worker's compensation insurance premiums, unemployment insurance contributions and social security taxes on the force account work, the contractor will receive the actual cost paid to which 20 percent (five percent profit and 15 percent overhead) will be added.

**109.5.3 Material.** For material accepted by the engineer and used, the contractor will receive the actual cost of such material delivered on the work, including transportation charges paid (exclusive of equipment rentals as hereinafter set forth), to which cost 20 percent (five percent profit and 15 percent overhead) will be added. For all material used in connection with, but not entering permanently into the work, reasonable depreciation will be allowed.

**109.5.4 Equipment.** For only that contractor-owned equipment necessary to accomplish the force account work, including all fuel and lubricants, tires, and repairs, the contractor will be allowed an hourly rate equal to the monthly rental rate divided by 176 hours as set out in the Rental Rate Blue Book for Construction Equipment on file in the office of the Commission at the time the work is begun. The allowed rates will be the rate adjustment factor multiplied by the bare hourly rates multiplied by the regional adjustment factor, plus the estimated operating cost per hour. The allowed time will be the actual operating time on the work. For the time required to move the equipment to and from the site of the work and any authorized standby time, the rate will be 50 percent of the hourly rate after the actual operating costs have been deducted. All allowed time shall fall within the authorized working hours for such extra work. No payment will be allowed for time elapsed while equipment is broken down or being replaced. The hourly rental rates will apply only to equipment that is already on the job. If the actual unit of equipment to be used is not listed in the schedule, the rate listed for similar equipment with the approximate same initial cost shall be used. Equipment to be used and all prices shall be agreed upon in writing before such equipment is used. An amount equal to 20 percent (five percent profit and 15 percent overhead) of the sum of these items will also be paid the contractor.

**109.5.4.1** Whenever it is necessary for the contractor to rent equipment, the rental and transportation costs of the equipment plus five percent for overhead will be paid. In no case

shall the rental rates exceed those of established distributors or equipment rental agencies. All prices shall be agreed upon in writing before such equipment is used.

**109.5.5 Miscellaneous.** No additional allowance will be made for general superintendence, the use of small tools or other costs for which no specific allowance is herein provided. Job site and home office overhead expenses shall be considered fully compensated by the percentage additions to costs provided in [Secs 109.5.1 through 109.5.6](#).

**109.5.6 Subcontracted Work.** For administration and all overhead costs in connection with approved subcontract work, the contractor will receive an amount equal to five percent of the actual cost of the subcontracted work.

**109.5.6.1** The engineer has authority to require alterations in the equipment and labor force assigned to force account work, to limit authorization of overtime work to that normally used on the project for work of similar nature or to require overtime work when an emergency exists, and to require the cessation of force account work when adverse conditions seriously limit productivity.

**109.5.7 Statements.** No payment will be made for work performed on a force account basis until the contractor has furnished the engineer with duplicate itemized statements of the cost of such force account work detailed as follows:

(a) Name, classification, date, daily hours, total hours, rate and extension for each laborer and foreman.

(b) Designation, dates, daily hours, total hours, rental rate and extension for each unit of machinery and equipment.

(c) Quantities of material, prices and extensions.

(d) Transportation of material.

(e) Cost of property damage, liability and worker's compensation insurance premiums, unemployment insurance contributions and social security.

**109.5.7.1** Statements shall be accompanied and supported by receipted invoices for all rental equipment, material used and transportation charges. However, if material used on the force account work are not specifically purchased for such work but are taken from the contractor's stock, then in lieu of the invoices the contractor shall furnish an affidavit certifying that such materials were taken from contractor's stock, that the quantity claimed was actually used, and that the price and transportation claimed represent the actual cost to the contractor.

**109.5.8 Compensation.** Each day the contractor's representative and the engineer shall compare records of the cost of work done as ordered on a force account basis. Two copies of these records will be made by the engineer on forms provided by the Commission, and they shall be signed at the end of each day by both the engineer and the contractor, one copy to be retained by the engineer and one given to the contractor. The total payment made as provided in [Sec 109.4](#) shall constitute full compensation for such work.

**109.6 Method of Payment.** Payment to the contractor for furnishing all material and performing all work under the contract will be deposited electronically in an account number and financial institution designated by the contractor on form MO 300-1278.

**109.7 Partial Payments.**

**109.7.1** The engineer will make semi-monthly payment estimates in writing of the material in place and the work performed during the semi-monthly interval and the value thereof at the contract unit bid prices. The proper percentage with relation to completion will be allowed for all incomplete items.

**109.7.2** The engineer may in any payment estimate include the value of any non-perishable material which will be finally incorporated in the completed work. The material shall be in conformity with the plans and specifications in the contract and shall not have been used at the time of such estimate. The value of such material in any one bid item shall not be less than \$1000. The material shall be delivered to the project or other location that is approved by the engineer. Any storage area not within the right of way shall be leased at the contractor's expense with provision for right of entry by the engineer during the period of storage. Invoices for material payment shall be submitted to the engineer at least four days prior to the estimate date. Receipted invoices for all material payments previously allowed on the estimate shall be submitted to the engineer within 42 days of the date of the estimate on which material allowance was made or such material allowance will be deducted from future payments. The amounts paid for such material shall go to reduce the amount of other partial or final payments due the contractor for the work performed as the materials are fabricated or incorporated in the completed work.

**109.7.2.1** No partial payment will be made for living or perishable plant material until planted.

**109.7.2.2** The engineer may also, on contracts containing 100 tons (100 Mg) or more of structural steel, include in the estimate prepared for partial payment, the value of structural carbon steel or structural low alloy steel, or both, which is to form a part of the completed work and which has been produced and delivered by the steel mill to the fabricator.

**109.7.2.2.1** The required receipted mill invoice, billing, title or assignment documents or other documents furnished by the contractor shall include certified mill test reports as described in [Sec 712.2.3](#), containing complete material description, identification, weights (masses), dimensions, heat and unit numbers, and cost data.

**109.7.2.2.2** The structural steel shall be stored separately and used only for the fabricated structural steel in the contract.

**109.7.2.2.3** The weight (mass) of the structural steel considered for partial payment shall not exceed the contract quantity.

**109.7.2.2.4** The payment of structural steel as described in [Sec 109.7.2.2](#) will not exceed 80 percent of receipted mill invoice value.

**109.7.2.3** The engineer may also include in any payment estimate an amount not to exceed 90 percent of the invoice value of any inspected and accepted fabricated structural steel items, fabricated structural aluminum sign trusses, structural precast items and permanent highway signs providing the total invoice value of these items is not less than \$25,000 for each storage location for each project.

**109.7.2.4** All material furnished for the work as noted in [Secs 109.7.2.2](#) and [109.7.2.3](#) shall be subject to shop inspection by the engineer.

**109.7.3** From the total amount of work items and material allowances of each estimate, there will be deducted five percent until the project is 50 percent complete after which no additional

amounts will be withheld. The retained percentage will be released as provided in [Sec 109.9](#). The net amount due on the estimate will be certified to the Commission for payment. This method of retained percentage does not apply to [Sec 808.6](#).

**109.8 Final Acceptance and Payment.** When the project has been accepted as provided in [Sec 105.15](#), the engineer will prepare the final tabulation of the quantities of work performed. After approval of such final tabulation by the contractor, the contractor will be paid the entire sum found to be due after deducting all previous payments and all amounts to be retained or deducted under the provisions of the contract. All prior partial estimates and payments will be subject to correction in the final tabulation and payment.

**109.8.1** Final acceptance will not prevent the Commission from correcting any measurement, estimate or certificate made before or after completion of the contract. The Commission will not be prevented from recovering, from the contractor or surety or both, overpayments sustained for failure to fulfill the obligations under the contract. A waiver on the part of the Commission of any breach of any part of the contract shall not be held to be a waiver of any other or subsequent breach.

**109.8.2** The contractor is liable to the Commission for latent defects, fraud or such gross mistakes as may amount to fraud, or as regards the Commission's rights under any warranty or guaranty without prejudice to the terms of the contract.

#### **109.9 Release of Retained Percentage.**

**109.9.1** As soon as practicable after the final acceptance of the work, and after final quantities have been computed or computations have reached a point where final quantities may be closely estimated, the retained percentage will be paid to the contractor. A portion of the retained percentage may be released after the project is open to all through traffic or the work has been essentially completed. Prior to any release of retained percentage the contractor shall file with the Commission:

(a) An affidavit, on the form prescribed by the Commission, to the effect that all payments have been made and all claims have been released for all material, labor and other items covered by the contract bond.

(b) The written consent of the surety to such payment.

(c) Any other documents which may be required by the contract.

**109.9.2** If said affidavit that claims have been paid cannot be given because of a dispute as to the amount or legality of a claim and if the contractor's affidavit clearly sets out the facts as to:

(a) The name and address of the unpaid claimant or claimants.

(b) The amount of the disputed claim.

(c) A brief statement of the cause of the dispute, the engineer, with the consent of the surety, may consent to and make payment of all of the final amounts and percentage due the contractor if the engineer is of the opinion that the claim has not been paid solely because the contractor is, in good faith, questioning the legality of said claim or its amount and if the engineer is further satisfied that there is good and sufficient bond to fully protect said claimant.

**109.10 Assignments.** No money due at the time, or which may become due, and no claim of any character because of any performance or breach of the contractor shall be assigned or transferred to any other person so as to bind or affect the Commission without the written consent of the surety and the Commission.

**109.11 Compensation for Project Delays.** This provision shall apply to all claims for additional compensation which are time related resulting from compensable project delays regardless of whether the cause of the claimed costs is described as: impact, indirect or consequential damages, inefficiency, standby, extended performance or by any other term.

**109.11.1** Only the actual and documented additional costs associated with the following items will be recoverable by the contractor as an equitable adjustment for delay.

- (a) Non-salaried labor expenses.
- (b) Costs for material.
- (c) Equipment costs.
- (d) Costs of extended job-site overhead.

(e) An additional ten percent of the total of items (a), (b), (c) and (d) for home office overhead and every other cost which no specific allowance is provided.

**109.11.2** All costs claimed must be adequately documented when measuring additional equipment expenses (i.e. ownership expenses) arising as a direct result of a delay caused by MoDOT. Use of equipment rental rate guides for this purpose is prohibited. Actual records kept in the usual course of business, measuring actual increased ownership expenses pursuant to generally accepted accounting principles is the only acceptable method.

**109.11.3** The parties agree that, in any adjustment for delay costs, MoDOT will have no liability for the following items of damages or expense.

- (a) Profit in excess of that provided herein.
- (b) Loss of profit.
- (c) Labor inefficiencies.
- (d) Equipment inefficiencies or reduced production.

(e) Home office overhead in excess of that provided in the percentage allowance in [Sec 109.11.1](#) or herein if none of those percentages applies.

(f) Consequential damages, including but not limited to loss of bonding capacity, loss of bidding opportunities and insolvency.

(g) Indirect costs or expenses of any nature.

(h) Attorney's fees, claims preparation expenses or costs of litigation.

**109.12 Change Orders.** Except as otherwise provided for in the change order, an adjustment of the contract price or time of contract performance in a change order constitutes compensation in full to the contractor and its subcontractors and suppliers for all costs and



time effects directly or indirectly attributable to the matter described in the change order, for all delays related thereto, for all impact, cumulative impacts and for performance of the change within the time stated.

## **SECTION 110**

### **STATE WAGE RATE REQUIREMENTS**

**110.1** The prevailing rate of wages, overtime and fringe benefits for the locality of the work as determined by the Department of Labor and Industrial Relations of Missouri, or by a court decision on appeal, will be contained in the bid documents by special provision. The contractor and all subcontractors shall pay not less than the prevailing rate of wages, overtime and fringe benefits as specified or as same may be changed by a court decision on appeal, for all work performed under the contract.

**110.2** The contractor is advised that the prevailing rate of wages, overtime and fringe benefits are subject to change during the life of the contract by court decision. No such change shall be the basis for adjustment in the contract price.

**110.3** The contractor and each subcontractor shall keep an accurate record showing the names and occupation of all workers employed by them, together with the actual wages, overtime and fringe benefits paid to each worker. The record shall be open to inspection at all reasonable hours by the representatives of the Department of Labor and Industrial Relations of Missouri or the Commission. The contractor shall submit certified copies of payrolls to the engineer each week.

**110.4** In the event of a conflict between any prevailing rate of wage, overtime or fringe benefits as determined by the Department of Labor and Industrial Relations and any minimum rate of wage, overtime or fringe benefits as determined by the Secretary of Labor, where the latter is applicable, the greater of the two shall apply.

# **DIVISION 200**

## ***CLEARING AND GRUBBING***



## SECTION 201

### CLEARING AND GRUBBING

**201.1 Description.** This work shall consist of clearing, grubbing, removing and disposing of vegetation within the limits of right of way and easement areas, except such vegetation as is designated to remain or to be selectively treated.

#### **201.2 Construction Requirements.**

**201.2.1** The engineer will establish right of way and construction lines and will designate all trees, shrubs and plants that are to remain. The contractor shall preserve without damage the vegetation designated to remain. All trees, stumps, brush and hedge not designated to remain shall be cleared, grubbed or cleared and grubbed as required and shall be disposed of in an acceptable manner.

**201.2.2** Stumps and roots in cut areas shall be grubbed to a depth of not less than 12 inches (300 mm) below the finished earth grade. Grubbing of Osage orange or locust hedge shall include removal of roots. In embankment areas, undisturbed stumps and roots extending not more than 6 inches (150 mm) above the ground line may remain, provided they are a minimum of 3 feet (900 mm) below the finished earth grade or the slope of the embankment. Except in areas to be excavated, stump holes shall be backfilled with suitable material and compacted to the approximate density of the adjacent area. In lieu of grubbing, stumps outside of the slope stake limits may be cut off not more than 3 inches (75 mm) above the ground. Grubbing of borrow areas, channel changes and inlet and outlet easements will be required only to the extent necessitated by the proposed construction.

**201.2.3** When burning is permissible under controlling air pollution regulations, all burning of products of clearing and grubbing shall be done under the care of a competent watchperson at such times and in such manner that neither vegetation on adjacent property nor that designated to remain on the right of way will be jeopardized. The burial of stumps and debris will not be permitted on the right of way. Products of clearing and grubbing may be removed from the right of way and disposed of out of sight from the roadway provided an acceptable written agreement with the property owner on whose property the products are placed is submitted by the contractor.

**201.2.4** Except in national forest areas, all timber not designated to remain and that has not been removed from the right of way prior to the beginning of construction shall become the property of the contractor. Low hanging and unsound or unsightly branches on trees or shrubs designated to remain shall be removed as directed and in accordance with good tree surgery practices.

**201.2.5 National Forest Land.** Before beginning work on a highway to be constructed over national forest land, the contractor shall obtain information from the forest ranger in charge as to the rules and regulations covering construction procedures. The contractor shall cut all merchantable timber into standard log lengths of 12 feet (3.7 m) or more, clean it of all twigs, limbs and tops, and pile the logs along the right of way. Merchantable timber will be considered any from which saw logs, pulpwood, posts, poles, ties or cordwood can be made. A burning permit shall be secured from the forest ranger in charge and the ranger shall be notified by the contractor before any fires are set. A zone extending 100 feet (30 m) each side from the centerline of the highway is contemplated to be a scenic zone and no area beyond

construction limits shall be marred or defaced by the contractor's equipment or construction procedures.

**201.2.6** The contractor shall scalp all areas where excavation or embankment is to be made, except that mowed or burned over sod need not be removed where the embankment to be constructed is 4 feet (1.2 m) high or more. Scalping shall include the removal of material such as sod, grass, residue of agricultural crops, sawdust and decayed vegetative matter from the surface of the ground without removing more earth than is necessary. The products of scalping shall be deposited at the toe of embankments where such areas are available within the limits of the roadway balance affected. If such areas are not available, the products shall be neatly and uniformly deposited on the right of way in such manner that no drainage will be blocked.

**201.2.7 Tree Clearing Time Restriction.** In counties north of the Missouri River, the contractor shall not clear trees which are considered suitable roosts for Indiana bats between April 1 and September 30, except as approved by the engineer. When clearing operations must be conducted during this restricted time period, the contractor shall notify the engineer at least 14 days prior to conducting the clearing so arrangements can be made to inspect each suitable tree to ensure Indiana bats are not present. Standing dead trees with loose or peeling bark and living shagbark hickories are considered suitable roosts when the trees are greater than 9 inches (225 mm) in diameter at 4 feet (1200 mm) above the ground.

### **201.3 Method of Measurement.**

**201.3.1** Separate measurement for clearing and grubbing will be made on an area basis to the nearest 1/10 acre (0.05 ha). An acre (hectare) consists of 87.12 (160) units, each unit being a rectangular area 50 feet (12.5 m) long and 10 feet (5 m) wide.

**201.3.2** The total area of the right of way, except that part secured for channel changes, inlet or outlet easements and borrow areas will be laid out in units beginning at the centerline of the highway with corners at whole or half stations and extending outward until all of the right of way has been included. The total area of the right of way secured for channel changes, inlet or outlet easements, or borrow areas will be laid out in units in the same manner from longitudinal base lines run or designated for these areas.

**201.3.3** Clearing and grubbing units will be counted independently of each other. Areas of mowing or scalping, small trees or brush 5 feet (1.5 m) high or less, and all weeds, cornstalks and similar material regardless of height, and the trimming of branches on trees and shrubs designated to remain, will not be measured. Only those stumps 3 inches (75 mm) or more in diameter 6 inches (150 mm) above the ground surface, in those areas where grubbing is required, will be considered in the measurement of grubbing. Stumps, regardless of height, that do not require grubbing but may be cut off near the ground line as provided in [Sec 201.2.2](#) will not be included as grubbing but will be measured as clearing.

**201.3.4** If any clearing or grubbing is performed within any unit, the entire area of that unit, except in the case of overlaps, will be included in the measurement. If individual trees or stumps cause the overlapping of units as laid out, only one unit of clearing or one unit of grubbing, as applicable, will be allowed. If a fractional unit occurs as a result of measurement or of overlap, the full area of the unit will be allowed. If the boundary line of any unit intersects a single tree or stump, counting of another applicable unit will not be made if there is any clearing or grubbing to be paid for in the adjacent unit. If the line between slope stakes intersects a grubbing unit in such manner that part of the unit contains grubbing and the remainder contains clearing, the entire area of such unit will be allowed for both clearing and grubbing payments.

**201.4 Basis of Payment.**

**201.4.1** The accepted quantities of clearing and grubbing will be paid for at the unit price for each of the pay items included in the contract.

**201.4.2** If no pay item for clearing or grubbing is included in the contract, clearing and grubbing, including scalping, will be considered incidental to the work and no direct payment will be made.

**201.4.3** No direct payment will be made for areas of mowing or scalping, removal of small trees or brush 5 feet (1.5 m) high or less, and all weeds, cornstalks and similar material regardless of height, and the trimming of branches on trees and shrubs designated to remain.

## **SECTION 202**

### **REMOVALS**

#### **SECTION 202.10 REMOVAL OF BRIDGES**

**202.11 Description.** This work shall consist of the removal and disposal of existing large structures noted on the plans.

#### **202.12 Construction Requirements.**

**202.12.1** The entire structure including all substructure units shall be removed to a point 2 feet (600 mm) below the finished ground line or streambed.

**202.12.2** All removed material, except guardrail, coldmilled material and other material stated in the contract, shall become the property of the contractor and shall be removed and disposed of by the contractor. Guardrail and coldmilled material shall remain the property of the Commission and shall be stockpiled as specified in the contract.

**202.12.3** Existing structures used for handling temporary traffic shall not be removed until the replacement structures are open to traffic. The contractor may make use of existing structures or portions of them during construction, but no material designated to be salvaged shall be removed from the project, cut, bent, broken or otherwise damaged.

**202.12.4** Any portion of an existing structure below the ground line which falls within the limits of excavation for new structures shall be removed and will be paid for as excavation for structures.

**202.13 Basis of Payment.** Payment for the removal and disposal of bridges will be made at the contract unit price.

#### **SECTION 202.20 REMOVAL OF IMPROVEMENTS**

#### **202.21 Description.**

**202.21.1** This work shall consist of the removal and disposal of all existing improvements, except those designated or permitted to be left in place or to be removed under other items of work, from the right of way and within the limits of any construction area outside the right of way.

**202.21.2** Removal of improvements shall include removing all buildings, drainage structures, pavements, surfacing and base courses of all types, curb, curb and gutter, sidewalks and house walks, steps, retaining walls, foundation walls, columns, footings, floors and any other types of building appurtenances, cisterns, catch basins, manholes, drainage and sewer pipes, water and gas main pipes, other objects or structures including scattered or piled bricks, stones, broken masonry, rubbish, debris, etc., from building demolition work and other existing improvements. This item shall also include the salvaging of material as designated in the contract, and the backfilling of the resulting trenches, holes and pits, and any grading work required to shape, smooth and finish the disturbed areas. All guardrail material within the right of way shall remain the property of the Commission and shall be stored on the right of way as directed by the engineer.



**202.21.3** The plans may not show a complete list of all items to be removed as there may be an undetermined number of abandoned utilities, basement or foundation walls, columns, footings, other types of building appurtenances, or other improvements encountered. The contractor shall determine the extent of the work to be performed under this item.

**202.22 Construction Requirements.**

**202.22.1** All buildings, disused structures, old pavements, abandoned sewers or pipe lines, or other obstructions to the construction of the roadway or within the limits of the right of way and not designated or permitted to remain, shall be removed or disposed of by the contractor as required. Existing structures used for handling temporary traffic shall not be removed until the replacement structures are open to traffic. The contractor may make use of existing structures or portions of them during construction, but no material designated for use elsewhere shall be removed from the project, cut, bent, broken or otherwise damaged.

**202.22.2** Material designated in the contract to be salvaged from existing structures shall be removed without damage, in sections which may be readily handled or transported, and shall be piled neatly at an accessible point. Material not designated for salvage will be considered the property of the contractor, unless owned and claimed by any political subdivision or utility company. Salvaged material becoming the property of the contractor shall not be stored upon the right of way, nor shall any portion of the right of way be used by the contractor as a sales yard. All discarded material or debris shall be disposed of at locations furnished by the contractor, or at locations on the right of way approved by the engineer.

**202.22.3** In removing pavement, curb, curb and gutter, gutters, sidewalk, and other similar improvements, and where a portion of such improvements are to be left in place, they shall be removed to an existing joint or to a joint sawed to a minimum depth of one inch (25 mm) with a true line and vertical face. Sufficient removal shall be made to provide for proper grades and connections in the new work regardless of any limits which may be indicated on the plans.

**202.22.4** Removal of concrete pavement or base course, concrete floors, basement floors and concrete sidewalk may consist either of breaking up and disposing of the broken concrete in embankments or in disposal areas furnished at the contractor's expense, or of breaking the slab into pieces not exceeding 4 square feet (0.5 m<sup>2</sup>) where new embankment over 24 inches (600 mm) high is to be placed over the slab. At locations designated on the plans where piling is to be driven, existing pavements, sidewalks, footings, foundations, walls and all other types of removal items shall be completely removed for a sufficient distance to permit piling to be driven. Existing improvements not removed in their entirety shall be removed to a minimum depth of 12 inches (300 mm) below the finished grading section or natural ground.

**202.22.5** All sewers, drainage pipes and floor drains which have been or are to be abandoned shall be permanently sealed at the ends with bulkheads constructed of Class B Concrete, concrete of a commercial mixture meeting the requirements of [Sec 501.14](#), or brick masonry, having a minimum thickness of 8 inches (200 mm). The use of salvaged brick will be permitted for constructing bulkheads provided the brick are clean and sound. No direct payment will be made for blocking abandoned sewers, drainage pipes or floor drains.

**202.22.6** All trenches, holes and pits resulting from the removal of improvements shall be filled with earth or with broken masonry and earth. No broken masonry shall extend closer than 12 inches (300 mm) to the finished surface. The material shall be placed in the same manner and compacted to approximately the same density as that required in adjoining areas.

**202.22.7** Removing and disposing of abandoned fences will be considered as included in final cleaning up of the right of way and no direct payment will be made for such work.

**202.23 Method of Measurement.** The work provided herein will not be measured for payment, but will be considered a lump sum unit. This shall include the removal of all items, whether in view or hidden underneath the surface of the ground, regardless of whether shown on the plans or encountered during construction. No deductions will be made from the volumes measured for payment of roadway excavation or Class 3 Excavation where existing improvements are removed from within the limits of the sections measured for determining pay volumes of excavation.

**202.24 Basis of Payment.** The accepted removal of improvements will be paid for at the contract lump sum price. If no lump sum unit for the removal of improvements is included in the contract, the removal of improvements required to complete the contract, or as directed by the engineer, will be considered incidental to the work and no direct payment for the removal will be made.

## SECTION 203

### ROADWAY AND DRAINAGE EXCAVATION, EMBANKMENT AND COMPACTION

**203.1 Description.** This work shall consist of excavation, disposal or compaction of all material encountered within the limits of the work not being removed under some other item. This work shall be performed in accordance with the specifications and in conformance with the lines, grades, thicknesses and typical cross sections shown on the plans, or established by the engineer. All excavation will be classified as hereafter described.

**203.1.1** Class A Excavation will consist of all roadway and drainage excavation not classified as Class C, Sandstone or Igneous Rock.

**203.1.2** Class C Excavation will consist of the removal of stone in ledges 6 inches (150 mm) thick or more. A ledge will be considered to be a continuous deposit of rock that may or may not include thin, interbedded seams of soft material or shale. The vertical limits of each ledge will be determined by beds of soft material or shale more than 12 inches (300 mm) thick. The beds of soft material or shale will be included in the measurement of Class A Excavation only. Boulders or other detached stones, each having a volume of 2 1/2 cubic yards (2 m<sup>3</sup>) or more, will be considered as Class C Excavation.

**203.1.2.1** Shale, fire clay, chert (joint flint rock) broken by intermittent clayey partings or clay seams, stratified chert cemented with clay seams (hardpan), and plain or bituminous-bound bases or surface courses of macadam, gravel, broken stone or similar material will not be considered as Class C Excavation or Sandstone Excavation.

**203.1.3** Sandstone Excavation will consist of the removal of material determined to be sandstone in ledge formation. Laboratory analysis will be made, if necessary, to aid in the determination.

**203.1.4** Igneous Rock Excavation will consist of the removal of rock of igneous origin (porphyry, granite, rhyolite) occurring in continuous formation, or of detached boulders having a volume of 2 1/2 cubic yards (2 m<sup>3</sup>) or more.

**203.1.5** Unclassified Excavation will consist of the excavation of all material of whatever character encountered in the work. All material excavated will be considered as Unclassified Excavation unless the contract specifies classified material.

#### **203.1.6 Borrow.**

**203.1.6.1** Borrow will consist of approved material required for the construction of embankment or for other portions of the work, and shall be obtained either from borrow areas shown on the plans, from areas designated by the engineer, or from other approved sources. The contractor shall notify the engineer sufficiently in advance of opening any borrow areas in order that the necessary cross sections or measurements may be taken. Borrow will be classified in the same manner as roadway excavation.

**203.1.6.2** The use of borrow areas other than those shown on the plans or designated by the engineer may be approved, provided:

(a) The material and area are equally satisfactory.

(b) The final cost to the Commission including the cost of easements is not greater than the cost as originally designated.

(c) The substitution is to the best interest of the Commission.

### **203.2 Construction Requirements.**

**203.2.1 General.** Prior to beginning excavation and embankment operations in any area, all necessary clearing, grubbing and stripping in that area shall have been performed. The excavation and embankment for roadway, intersections and entrances shall be made to the designated alignment, grade and cross section. Side slopes, cuts and fills shall be finished to a reasonably smooth and uniform surface that will merge with the adjacent terrain without variations readily discernible from the road. Finishing by hand methods will not be required, except that all brush, weeds, excess mud and silt, or other debris shall be removed from culverts and channels within the scope of the work in accordance with [Sec 104.11.2](#) even though such structures are used in place. Areas disturbed by the contractor outside the limits of construction shall be restored at the contractor's expense to a condition similar to that prior to construction operations.

**203.2.1.1 Field Stone.** All loose field stone within the limits of the right of way, field stone necessary to be removed before beginning operations on light grading sections, and small rocks and boulders resulting from the operations of subgrade scarifying and finishing a graded earth roadway shall be disposed of as directed by the engineer.

**203.2.1.2 Shoulders.** Earth shoulders shall be constructed of suitable material to the grade and cross section shown on the plans and shall be compacted by use of a steel wheel roller weighing not less than 5 tons (4.5 Mg). The construction of shoulders shall start when sufficient surfacing has been completed and attained satisfactory strength to permit continuous shouldering operations. Equipment that will damage the surfacing will be prohibited from operating on the surfacing during shouldering operations. Surfacing and curbs shall be protected where equipment is crossing or turning.

**203.2.1.3 Grading for Aggregate Type Surface Roadway.** If a roadway to receive an aggregate type surface is specified in the contract, reasonable tolerance in alignment, grade and cross section will be permitted. A reasonable tolerance in alignment will mean a maximum gradual deviation of 2 feet (600 mm), free from sharp breaks, made in the interest of economy and to take advantage of favorable topography. A reasonable tolerance in grade will mean a final grade that is uniform in appearance, free from sharp breaks or humps, and within 6 inches (150 mm) of plan grade if such tolerance results in economy to the Commission. Economy to the Commission does not refer to each individual cut, but to the entire project after due consideration has been given to the need of the material removed from cuts that are below grade and to the compensating feature of cuts that are left above grade. Loose or embedded rock in the roadbed surface over 2 inches (50 mm) in size shall be removed, picked up and disposed of as directed by the engineer.

**203.2.2 Maintenance.** During construction, the roadway shall be maintained by the contractor in such condition that it will be passable and well drained at all times. Roadway ditches, channel changes, inlet and outlet ditches, and any other ditches in connection with the roadway shall be cut and maintained to the required cross section. All drainage work shall be performed in proper sequence with other operations. All ditches and channels shall be kept free of debris or obstructions. All material resulting from slides shall be removed and disposed of as directed by the engineer.

**203.2.3 Drilled and Dug Wells.** The contractor shall notify the engineer at least 24 hours in advance of the contractor's intent to plug the well. The contractor shall be in possession of a valid Department of Natural Resources permit for well or pump installation. Reference to Department of Natural Resources regulations are from the version in effect at the time of bid opening.

**203.2.3.1** Abandonment procedure for wells shall be in accordance with requirements set forth in the Department of Natural Resources regulations, specifically as follows:

Type of Well	Regulation
Monitoring Wells	10 CSR 23-4.080
Heat Pump Wells	10 CSR 23-5.080
Test Holes	10 CSR 23-6.050
All Other Wells	10 CSR 23-3.110

**203.2.3.2** Cisterns shall be pumped out and plugged by filling the lower one-half to three-fourths of the cistern with clean fill, such as coarse gravel or rock, agricultural lime or sand. The cistern walls above the fill shall then be pushed in and the remainder of the cistern filled to the ground line or within 12 inches (300 mm) of the finished grading section, whichever is lower, with clay or clay-rich soil compacted in 6-inch (150 mm) layers to the approximate density of the adjacent soil.

**203.2.3.3** Direct payment will not be made for the plugging or disposal of wells or cisterns. The contractor shall be responsible for the costs and fees associated with the registration of these wells. A copy of the completed registration form shall be furnished to the engineer.

**203.2.4 Subgrade Scarifying.** The engineer may order subgrade scarifying performed to remove oversize material if the upper 6 inches (150 mm) of the subgrade as tentatively completed contains material of a dimension greater than 4 inches (100 mm) sufficient in quantity to make it unacceptable as a roadbed for the proposed type of surfacing.

**203.2.5 Excavating in Rock.** Excavating and undergrading in rock (i.e., material conforming to the description of Class C, Sandstone or Igneous Rock, whether the contract calls for classified or unclassified excavation) shall be performed in a manner to produce material of such size as to permit being placed in embankments in accordance with the requirements. Rock within the roadbed limits shall be removed to the limits of undergrading insofar as practicable and in such manner as to leave no undrained pockets in the surface. Care shall be taken to avoid overshooting when blasting. Any loose or shattered rock, overhanging ledges and boulders above the roadbed which might dislodge shall be removed. If the contract provides a specific use for rock from roadway excavation, the work shall be performed in such order and manner as may be necessary to ensure that the desired quantity of such material may be placed as required.

**203.2.5.1** Reporting for all blasting shall be made in accordance with [Sec 107.7](#).

**203.2.5.1.1** The contractor shall submit a rock excavation blasting plan to the engineer at least 14 days before drilling operations begin. The blasting plan shall address all trenching, presplitting and production shots and shall include, but is not limited to the following information: powder factor per cubic yard (cubic meter), hole size, subdrill, stemming depth, drill pattern, type of explosives and detonators, and safety precautions. A preblast survey shall be required on all uncontrolled structures within 500 feet (150 m) of planned blasting operations. A separate blasting plan shall be required on all locations requiring blasting within

50 feet (15 m) of any roadway structure. Any changes to blasting plans shall be provided to the engineer for review prior to performing the work.

**203.2.5.1.2** The contractor shall not exceed blasting holes larger than 4 inches (100 mm) in diameter. The powder factor shall be between 0.60 to 1.35 pounds per cubic yard (0.36 to 0.80 kg/m<sup>3</sup>) except for presplitting or trenching. If stemming ejection becomes a problem, crushed stone stemmings shall be used. Subdrill shall be no more than 30 percent of burden. The contractor shall not drill within a radius equal to the depth of the cut of a loaded borehole. Seismic monitoring shall be required when the scaled distance is less than 65 (30), where scaled distance equals the distance, in feet (meters), divided by the square root of explosive weight (mass), in pounds (kilograms), per 8 millisecond delay.

**203.2.5.1.3** The contractor shall perform the excavation of rock cuts by the technique of presplitting, cushion blasting or air decking to produce a neat line of the proposed excavation, with the results subject to the approval of the engineer. Holes for presplitting shall be drilled to the full depth of the cut or to a pre-selected bench elevation as shown on the plans or as determined by the engineer. Presplitting shall be done according to accepted practice to produce a clean face on the excavated cut. Presplit shots shall be made prior to production shots. Production holes shall not be drilled any closer to the presplit line than 12 times the diameter of the production blast hole.

**203.2.5.2 Undergrading.** Areas of required undergrading shall be backfilled with one of the following material with preference in the order given, dependent on availability:

(a) Rock fragments or spalls.

(b) A granular type material having a plasticity index not to exceed 10 and a gradation such that at least 50 percent of the material will be retained on the No. 4 (4.75 mm) sieve.

(c) A material having a low plasticity index and designated by the engineer as suitable.

**203.2.5.3 Overbreak.** Overbreak resulting from blasting rock below the limits of undergrading shall be removed and backfilled with spalls or rock fragments at the contractor's expense. If spalls are not available and if the contractor does not elect to use rock fragments, the use of either of the following will be satisfactory.

(a) Material meeting the requirements of [Sec 1007](#).

(b) A granular type material having a plasticity index not to exceed 10 and a gradation such that at least 50 percent of the material will be retained on the No. 4 (4.75 mm) sieve.

**203.2.5.4** If a roadway to receive an aggregate type surface is specified in the contract, undergraded areas shall be backfilled with material obtained from roadway excavation and the upper 6 inches (150 mm) shall be free of granular material larger than 4 inches (100 mm).

**203.2.6** Where excavation to the finished graded section results in a subgrade or slopes of unsuitable material, the engineer may require the contractor to remove the unsuitable material, and backfill to the finished graded section with approved material. The contractor shall conduct the operations in such manner that the engineer may make the necessary measurements before the backfill is placed.

**203.2.7** Borrow material shall not be placed until after material from roadway excavation has been placed in the embankment, except as approved otherwise by the engineer. The contractor shall not excavate beyond the dimensions and elevations established, and no material shall be removed prior to staking and cross sectioning the site. If the contractor places more borrow than required and thereby causes a waste of excavation, such waste will be deducted from the borrow volume as measured in the borrow area. All borrow areas shall be bladed and left in such shape as to permit taking the necessary cross sections after excavating has been completed. The finished borrow areas shall be approximately true to line and grade if so specified in the contract, and shall be finished, where practicable, so that no water will collect or stand therein. If necessary to remove fencing in order to obtain borrow material, it shall be replaced in as good condition as it was at the time of removal. The contractor shall be responsible for confining livestock when a portion of the fence is removed. No direct payment will be made for removing and replacing such fence nor for the confining of livestock.

**203.2.8** Obliteration of old roads shall be performed in areas shown on the plans and shall include all grading operations necessary to incorporate the old road into the work. The obliteration shall provide a pleasing appearance. Removal of portland cement concrete pavement and concrete base course will be paid for in accordance with [Sec 202.20](#). The earthwork for obliteration, including the obliteration of bituminous surfacing, will be paid for as roadway excavation, unless otherwise provided in the contract.

**203.2.9 Human, Criminal, Historical, Archaeological or Geological Remains.** If the contractor encounters any remains, items, sites or artifacts which may be of criminal, historical, archaeological or geological significance, such as any human remains, historic or prehistoric sites, artifacts, bones or fossils, the engineer shall be notified immediately. All excavation operations within 50 feet (15 m) of the finding shall be temporarily suspended and shall not be resumed at that location except as authorized by the engineer. The engineer will determine the disposition of the remains or items found. Such remains or items shall not be disturbed or removed, except as directed by the engineer. If directed by the engineer, the contractor shall excavate the site in such manner as to preserve the items encountered.

**203.2.9.1** If a temporary suspension of work under this section lasts for an unreasonable period of time, as defined in [Sec 108.15.1](#), and it results in an actual increase in the time or cost of performance of the contract, then this condition shall be deemed a suspension of the work ordered by the engineer under [Sec 108.15](#) and shall be handled in accordance with that section.

**203.2.10** During the process of excavating cuts, the engineer may order specific excavated material placed in stockpiles in order to have suitable material available to complete the upper portion of embankments and to backfill portions of undergraded cuts.

**203.2.11 Embankment Construction.** Embankment construction shall consist of constructing roadway embankments, including preparation of the areas upon which they are to be placed, constructing dikes and berms, placing and compacting approved material within roadway areas where unsuitable material has been removed, and placing and compacting of embankment material in holes, pits and other depressions within the roadway area. Only approved material free of trees, stumps, rubbish and any other deleterious material shall be used in the construction of embankments and backfills. Rocks, broken concrete or other solid material shall not be placed in embankment areas where piling is to be placed or driven.

**203.2.11.1** Embankments requiring surcharges, restricted loading rates, embankment control stakes or pore pressure measurement devices shall be constructed to the design template progressively for the full height. Failure of embankments or embankment foundations, or damage to structures which occurs when the contractor fails to observe restricted loading rates,

or fails to construct slopes initially to the design template shall be repaired as directed by the engineer at the contractor's expense.

**203.2.11.2** Construction of embankments shall not be started on foundation soil or partially completed embankments having more than 0.2 foot (60 mm) of frost, nor shall embankment be built of frozen material. Frost layers in partially completed embankments shall not be less than 18 inches (450 mm) apart. No material shall be placed on frost layers encountered within 12 inches (300 mm) of the top of the proposed grading section. Frozen material on foundation soil or partially completed embankment not meeting the above requirements shall be removed before placing material for the embankment. The removal of frozen material from the foundation of an embankment, or from any layer of the embankment, and the replacement with satisfactory material shall be at the expense of the contractor.

**203.2.12** Where embankment is to be placed on hillsides or where new embankment is to be constructed against existing embankments, the existing slopes that are steeper than six horizontal to one vertical measured at right angle to the roadway shall be continuously benched in not less than 12-inch (300 mm) rises over those areas where it is required as the work is brought up in layers. Benching shall be of sufficient width to permit placing and compacting operations. Each horizontal cut shall begin at the intersection of the ground line and the vertical side of the previous bench. Existing slopes shall also be stepped to prevent any wedging action of the embankment against structures. No direct payment will be made for the material thus cut out nor for its compaction along with the new embankment material.

**203.2.13** Scalping shall be performed in accordance with [Sec 201.2.6](#). Where an embankment less than 4 feet (1.2 m) high is to be made, all sod and vegetative material shall be removed from the surface upon which the embankment is to be placed, and the cleared surface completely broken up by plowing, scarifying or stepping to a minimum depth of 6 inches (150 mm). This area shall be compacted in the same manner as that required for the embankment placed on the area. Sod not required to be removed shall be thoroughly disked before construction of embankment. Where an embankment less than 3 feet (900 mm) high is to be made over a compacted road surface containing bituminous or granular material, the old road surface shall be scarified to a depth of at least 6 inches (150 mm). This scarified material shall be recompacted.

**203.2.14** If embankment is deposited on one side only of abutments, wingwalls, piers or culvert headwalls, care shall be taken that the area immediately adjacent to the structure is not compacted to the extent that it will cause overturning of or excessive pressure against the structure. Equipment of such weight (mass) as may cause damage to culverts or other structures will not be permitted to work over or immediately adjacent to such structures. The embankment adjacent to the end bent of a bridge shall not be placed higher behind than in front of end bents until the superstructure is in place. If embankment is to be placed on both sides of a concrete wall or box type structure, operations shall be so conducted that the embankment is kept at approximately the same elevation on each side.

**203.2.15** Surcharged embankments shall be built in accordance with the plans and shall remain in place for such time as required by the contract. The requirements for placing and compacting will be waived on the surcharge material above the specified compacted area.

**203.2.16** All excess or unsuitable excavated material, including rock and boulders that cannot be used in embankments may be placed on the side slopes of the nearest embankment in a satisfactory manner or shall be disposed of off the right of way in areas obtained by the contractor. Rock or boulders greater than 24 inches (600 mm) shall not be used routinely in constructing side slope embankments. A distinct shoulder line shall be maintained by keeping



all such waste material at least 24 inches (600 mm) below the finished shoulder elevation, and specific density control will not be required.

**203.2.17** Roadway embankment shall be placed in layers not exceeding 8 inches (200 mm) (loose measurement) and shall be compacted as specified before the next layer is placed. The layers shall be placed approximately parallel to both the proposed profile grade and to the finished roadbed. Effective spreading equipment shall be used on each lift to obtain uniform thickness prior to compacting. Continuous leveling and manipulating will be required during compacting operations. Construction equipment shall be routed uniformly over the entire surface of each layer. Occasional rock and boulders greater than 24 inches (600 mm) shall be dispersed to allow for uniform compaction between them.

**203.2.17.1** Occasional stones or rock fragments exceeding the thickness of the 8-inch (200 mm) layer shall be disposed of by being incorporated into the embankment outside the limits of the proposed surfaced traffic lanes. The thickness of the layer in these areas may be increased if necessary to accommodate the stones, but shall not exceed 12 inches (300 mm) (loose measurement). The stones or rock fragments are to be placed so there will be no nesting.

**203.2.17.2** Lifts may be increased to a maximum of 12 inches (300 mm) thick (loose measurement) for berms, filling of old channels, waste or similar areas, and any roadway or approach for which a granular type surface is proposed. These areas shall be compacted by uniformly distributing all equipment movements over the entire area, and specific density control will not be required. No direct payment will be made for compaction performed in these areas.

**203.2.18** If the excavated material consists predominantly of rock fragments of such size that the material cannot be placed in layers of the thickness prescribed, such material shall be placed in the embankment in layers having a thickness of the approximate average size of the larger rocks but not to exceed 24 inches (600 mm). Rocks or boulders too large to permit placing in a 24-inch (600 mm) layer shall be reduced in size as necessary to permit this placement. Rock shall not be dumped in place, but shall be distributed by blading or dozing in a manner to ensure proper placement in final position in the embankment. The spalls and smaller stone fragments shall be left on the surface of each layer as formed. The uppermost portion of rock embankments placed in this manner shall be constructed as follows:

(a) If the specified or proposed surfacing consists of a rigid or flexible type pavement, the top consolidated rock layer for the full width between roadbed slopes shall be finished to the same limits as shown on the plans for undergrading in rock cuts. If rigid pavement is to be constructed without an aggregate base, the material requirements of [Sec 203.2.5.2](#) shall govern for the construction of the area between the bottom of the pavement and the top of the top consolidated rock layer. Any embankment necessary outside the limits of the pavement shall be constructed of suitable earth or as otherwise specified in the contract.

(b) If the specified or proposed surfacing consists of a treated or untreated earth surface, or any aggregate type surface, the top 6 inches (150 mm) of finished roadbed embankment shall be constructed of suitable earth. If subgrade scarifying is then considered necessary, the engineer will so order and payment will be made under the item of Subgrade Scarifying.

**203.3 Compaction of Embankment and Treatment of Cut Areas with Moisture and Density Control.** AASHTO T 99, Method C, replacing any material retained on a 3/4-inch (19.0 mm) sieve, as provided therein, or MoDOT Test Method T40 will be used as the Standard Compaction Test for determining the moisture density relations of soils. The

optimum moisture as determined by the Standard Compaction Test may be used as a guide in determining the proper moisture content at which each soil type should be compacted. Water shall be added or removed as necessary to permit obtaining the required density and moisture control. The field density of the embankment after compaction will be determined in accordance with AASHTO T 191 or T 205, using the total material or T 238, Method B Direct Transmission, for wet density. The volume of the test hole may be reduced as necessary to accommodate available testing equipment. If nuclear density methods are used, moisture content will be determined in accordance with AASHTO T 239, except that a moisture correction factor will be determined for each soil in accordance with MoDOT Test Method T35. The calculated density obtained in a field density test will be compared with the maximum density as established by the Standard Compaction Test to determine the percent compaction attained.

**203.3.1** If payment of compaction is specified as a pay item of the contract, compaction to at least 90 percent of maximum density, as determined by the Standard Compaction Test, will be required in the following areas:

(a) All roadway embankments except as otherwise provided in the following sections: [Secs 203.2.15, 203.2.16, 203.2.17.2, 203.3.3, 203.3.4, 203.3.5 and 203.3.7.](#)

(b) All backfilled undergraded cuts, except as modified by [Sec 203.3.3.](#)

(c) Certain portions of the roadbed in cuts specified in [Sec 203.3.8](#), except as modified in [Sec 203.3.3.](#)

**203.3.2** The moisture content of the soil at the time of compaction shall be as herein specified.

**203.3.2.1** When necessary to eliminate rubbery condition of the embankment, it may be required that some soils have a moisture content below the optimum during compacting work; except that Class A material having liquid limits of 40 or more where placed in embankments within 5 feet (1.5 m) of the top of the finished subgrade or where encountered in areas of cut compaction, shall be compacted at not less than optimum moisture content. The liquid limit determination will be as set forth in AASHTO T 89. Some Class A material including heavy clays and material commonly known as shales and fireclays will require breaking down so that the moisture can be uniformly distributed.

**203.3.2.2** Loessial soils shall have moisture controlled so as not to exceed optimum plus 3 percentage points when placed in embankments less than 30 feet (9 m) high. Such soils when placed in embankments 30 feet (9 m) high or more shall have moisture controlled so as not to exceed optimum moisture. If wet foundation conditions contribute to the embankment moisture while compacting, the engineer may waive this specified moisture content for a height not to exceed 3 feet (1 m) above the embankment foundation. In the event of conflict of provisions of this section with provisions in [Sec 203.3.2.1, Sec 203.3.2.1](#) shall govern.

**203.3.3** The upper 18 inches (450 mm) of the earth subgrade extending the full width between roadbed slopes shall be compacted to at least 95 percent of maximum density.

**203.3.4** Roadway embankment within 100 feet (30 m) of each end of a structure on which the top slab or deck is to be used as the riding surface and the spill fill under such a structure shall be compacted to not less than 95 percent of maximum density.

**203.3.5** Density requirements will not apply to portions of embankments constructed of material so rocky that they cannot be satisfactorily tested in accordance with AASHTO T 191 or T 205. Material of a gradation having more than approximately 20 percent retained on a

3/4-inch (19.0 mm) sieve will generally be considered too rocky for satisfactory density testing. In lieu thereof, compactive effort on rock and rocky material shall consist of making four complete coverages of each layer with a tamping-type roller or two complete coverages of each layer with a vibratory roller. The tamping-type roller shall have tampers or feet protruding not less than 6 inches (150 mm) from the surface of the drum and have a minimum load on each tamper of 250 pounds per square inch (1700 kPa) of tamping area. The vibratory roller shall have a manufacturer's rating of 16 to 20 tons (14 to 18 Mg) compacting power. During compaction, each layer shall have the moisture content controlled such that, in the judgment of the engineer, any silt and clay fraction is in a plastic state. Simple diagnostic tests to establish such a plastic state include ability to indent with thumb or heel or to roll a short thread of soil between the hands. Material which crumbles under pressure will be considered too dry.

**203.3.6** Each layer shall be wetted or dried, as necessary, and shall be compacted to the required density. Regardless of the type of equipment used, the roadway shall be compacted uniformly and the surface kept reasonably smooth at all times. If large pieces of heavy clay are encountered, the material shall be broken down by suitable manipulation to permit satisfactory embankment construction. If shale is encountered, it shall be broken down as much as is practicable and compacted at or above optimum moisture.

**203.3.7** Compaction to at least 95 percent of maximum density will be required for that portion of any embankment below an elevation 50 feet (15 m) below the top of the finished subgrade. If, because of embankment foundation conditions, the 95 percent of maximum density cannot be obtained after reasonable compactive effort has been expended, the engineer may waive the 95 percent requirement for a height not to exceed 3 feet (1 m) above the embankment foundation.

**203.3.8 Compacting in Cut.** Cut compaction shall be performed in all Class A material areas, after removal of the roadway excavation material to the required section. A surface parallel to the pavement slope, 12 inches (300 mm) below the bottom of the pavement or lowest base course, shall be temporarily exposed for the full width between roadway inslopes. The exposed material, to a depth of 6 inches (150 mm), shall be manipulated and compacted to not less than the required density. The material above this compacted plane shall be spread in layers not exceeding 8-inch (200 mm) loose thickness, each layer being wetted or dried as necessary and compacted to the specified density. The entire volume of material so handled and compacted, including the 6-inch (150 mm) layer compacted in place, will be considered as Compacting in Cut. All Class A material having a liquid limit of 40 or more including the 6-inch (150 mm) layer compacted in place shall be compacted at not less than optimum moisture content.

**203.3.8.1** Cut compaction shall be performed to an additional depth of 12 inches (300 mm) for 50 feet (15 m) on each side of the intersection of the natural ground and the top of the subgrade, then graded uniformly for 30 feet (9 m) to meet the depth requirements of [Sec 203.3.8](#) and, if necessary, [Sec 203.3.8.2](#).

**203.3.8.2** The existing ground for the full width between roadway slopes under embankments of less than 18 inches (450 mm) high shall be treated in accordance with [Sec 203.3.8](#) to only such depth as to ensure having 18 inches (450 mm) of material of the required density and moisture below the top of the finished subgrade.

**203.3.9 Field Laboratory.** When authorized by the engineer, the contractor shall provide a Type 2 Field Laboratory meeting the requirements of [Sec 601](#). Payment for the laboratory will be made as provided in [Sec 601](#).

**203.4 Compaction of Embankment not Constructed with Density or Moisture and Density Control.** If compaction of embankment is a requirement of the contract but has not been specified as a pay item, the compactive effort on each layer shall consist of distributing all equipment movements over the entire embankment area and of at least three complete coverages with a tamping-type roller over the entire area to be compacted. The tamping-type roller shall have tampers or feet projecting not less than 6 inches (150 mm) from the surface of the drum and shall have a minimum load on each tamper of 250 pounds per square inch (1700 kPa) of tamping area. Compactive effort shall be continued, if necessary, until the tamping feet penetrate not more than 2 inches (50 mm) into the layer of material being compacted. Continuous leveling and manipulating will be required during compacting operations and the moisture content shall be adjusted as necessary, in the judgment of the engineer, to permit proper consolidation.

**203.4.1** Dumping and rolling areas shall be kept separate, and no lift shall be covered by another until compaction complying with these requirements has been attained. Unstable areas in the embankment shall be removed and replaced with suitable material at the contractor's expense.

**203.4.2** Each layer of embankment constructed of rock or rocky material shall also be compacted by three complete coverages of the tamping-type roller. A vibratory roller may be used if approved by the engineer.

**203.5 Compaction of Embankment Without Specified Compaction Results or Specified Compaction Equipment.** If compaction of embankment is not designated by the contract, no compaction will be required other than that attained by distributing equipment movements over the entire embankment area.

#### **203.6 Method Of Measurement.**

**203.6.1 Contract Quantity Payment.** The quantities of excavation and compacting embankment for which payment will be made are those shown in the contract for the various items, provided the project is constructed essentially to the lines and grades shown on the plans. A partial check of existing ground elevations will be made at the time slope stakes are set, and of the finished work for deviations in the grade, width or slope from the authorized grade or typical section. Contract quantities will be used for final payment of Class A Excavation, Unclassified Excavation and Compacting Embankment except when:

- (a) Errors are found in the original computations.
- (b) An original cross section is found to have an average deviation from the true elevation in excess of one foot (300 mm).
- (c) An authorized change in grade, slope or typical section is made.
- (d) Unauthorized deviations decrease the quantities on the plans.
- (e) Class C, Sandstone or Igneous Rock Excavation is encountered, unless the contract calls for unclassified excavation. If the above conditions are encountered, the corrections or revisions will be computed and added to or deducted from the contract quantity.
- (f) Quantities are determined by measurement as specified in [Sec 203.6.2](#).

**203.6.1.1** If the plans have been altered or when disagreement exists between the contractor and the engineer as to the accuracy of the plan quantities of any balance, or the entire project,

either party has the right to request a recomputation of contract quantities of excavation within any area by written notice to the other party. The written notice shall contain evidence that an error exists in the original groundline elevation or in the original computations which will materially affect the final payment quantity. If such final measurement is required, it will be made from the latest available ground surface and the design section.

**203.6.2 Measured Quantities.** If payment of excavation is to be made on a measured quantity basis, volumes of authorized excavation will be computed from cross section measurements by the average end area method. When not attributable to carelessness of the contractor, slides in Class A Excavation and in Unclassified Excavation will be included in such measurements. Authorized excavation of rock, shale, muck or other unsuitable material will also be included.

**203.6.2.1** Authorized excavation of rock, shale, muck or other unsuitable material below grade shall consist of that excavation necessary to provide the designated depth of undergrading. No measurement or payment will be made of any material removed and replaced below the design limits of undergrading. No measurement will be made for overbreakage or for the disposal of the same if such material is obtained from outside the neat lines of the proposed backslopes in rock excavation except that such overbreakage will be measured as Class A Excavation or Unclassified Excavation, as applicable, when all suitable authorized excavation has been used and the overbreak material is required for completion of the embankment. A maximum tolerance of one foot (300 mm) will be permitted for rock protruding or extending within the neat lines of the proposed backslopes.

**203.6.2.2** While work involving classified excavation is in progress, the engineer will fix points of elevation and stationing as required to establish the lines of demarcation between the material of different classification. These top points will be determined before any Class C, Sandstone or Igneous Rock Excavation is removed, and it shall be the contractor's responsibility to notify the engineer before removing any such material. Any excavation removed before the engineer has been notified and given 24 hours to establish lines of demarcation will be included in the measurement of Class A Excavation only.

**203.6.2.3** Excavation may be encountered in which lines of demarcation between material of different classifications are impracticable to establish. The quantity of material classified as other than Class A Excavation may be determined by the engineer on a percentage basis as the work progresses after the limits of determinate classification material have been established.

**203.6.2.4** Measured quantities of excavation will be used where the ground elevations shown on the plans are found to be erroneous. No revision of contract quantities will be made if the actual ground elevations are considered to agree generally with the ground line shown on the plans. Where the engineer authorizes a change in grade, slope or typical section affecting the volume of excavation allowed for payment in that particular balance or area, the revised volume will be determined by the average end area method on the basis of the revised grade, slope or typical section. Where unauthorized deviations result in a decrease in the contract quantities, the deviations will be measured and deducted from the contract quantity.

**203.6.2.5** The quantity of Class C, Sandstone or Igneous Rock Excavation will be computed on a measured quantity basis. The volume of Class A Excavation allowed for payment in roadway balances involving rock excavation will be determined by one of the following methods, whichever in the judgment of the engineer is more applicable:

(a) Measuring and computing both the Class A Excavation and the Class C, Sandstone or Igneous Rock Excavation within the limits affected.

(b) Deducting the volume of Class C, Sandstone or Igneous Rock Excavation from the total adjusted volume of roadway excavation, regardless of classification, within the limits affected.

**203.6.2.6** Measurement will be made for unsuitable material actually excavated and removed to permit proper compaction in cut sections and in foundations for embankment sections. No measurement will be made of the suitable material temporarily removed, and replaced, to facilitate compaction in cuts or under shallow embankments.

**203.6.2.7** Borrow quantities will be determined by measuring the borrow area before and after excavating.

**203.6.2.8** Excavated material stockpiled in accordance with [Sec 203.2.10](#) will be measured in the stockpile by the average end area method.

**203.6.2.9** Only that material placed in accordance with the requirements of [Sec 203.3](#) will be included in the measurement of Compacting Embankment. If an error has been found in the original computations or ground elevations, or if there has been an authorized change in grade, slope or typical section, the plan quantity for Compacting Embankment for those areas or balances affected will be adjusted for final payment. All required compaction above the original ground line and all compacting of material placed in undergraded cut sections will be considered as Compacting Embankment.

**203.6.2.10** Compacting in cuts will be measured to the nearest 1/10 station (5 m) along the centerline of each roadbed, regardless of width, and will include any required compaction of the original ground under shallow embankments. For the purpose of measurement, a divided highway will be considered as having two roadbeds. Measurement of ramps will be made from or to a point opposite the intersection of the outer edge of the pavement on the thruway, or its widening, and the inner edge of the pavement on the ramp. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**203.6.2.11** Measurement of roadway and drainage excavation and compacting embankments will be made to the nearest cubic yard (cubic meter).

**203.7 Basis of Payment.** Payment for roadway and drainage excavation will be made at the contract unit price per cubic yard (cubic meter) which price shall be full compensation for the excavating and hauling; placing and forming of embankments; preparation of subgrade; shouldering, rounding slopes, obliterating old roadway, finishing of graded earth roadway, picking up and disposing of field stone and other rock; and any work noted on the plans to be included in the contract unit price for excavation. No payment will be made for any material used for purposes other than those designated, except as approved by the engineer.

**203.7.1** Payment will be made at the contract unit price per cubic yard (cubic meter) for the applicable item of Class A Excavation or Unclassified Excavation for each handling of stockpiled excavation approved by the engineer.

**203.7.2** No payment will be made for rock overbreak or for backfilling overbreak areas below the undergrading limits. Payment for the material for backfilling required undergraded areas will be made under an applicable excavation item. No direct payment will be made for backfilling around structures, the excavation for which has been paid for as roadway excavation.

**203.7.3** If the contract contains a unit price for either Sandstone or Class C Excavation, but not both, it shall apply to the other if both are encountered. Payment will be made at four times the contract unit price per cubic yard (cubic meter) for Class A Excavation if the contract does not contain a unit price for either Sandstone or Class C Excavation and such material is encountered, unless the project is let on an unclassified excavation basis. The unit price per cubic yard (cubic meter) established in this manner shall apply regardless of quantities involved.

**203.7.4** If the contract does not contain a unit price for Igneous Rock Excavation and such material is encountered during construction, payment will be made at a unit price of \$4.00 per cubic yard (\$5.25/m<sup>3</sup>) regardless of quantity, unless the project is let on an unclassified excavation basis.

**203.7.5** No direct payment will be made for water required in compaction work. Any costs involved in reducing the moisture content in soils will be at the contractor's expense.

**203.7.6** Payment for finishing a graded earth roadway will be considered completely covered by the contract unit price for the various classes of excavation except as otherwise specifically noted under [Sec 104.11.2](#) in regard to material excavated in cleaning channels and culverts used in place.

**203.7.7** Payment will be made at the unit price for each of the pay items included in the contract.

## SECTION 204

### EMBANKMENT CONTROL

#### SECTION 204.10 EMBANKMENT CONTROL STAKES

**204.11 Description.** This work shall consist of furnishing, setting and monitoring embankment control stakes for detection of earth movement.

**204.12 Material.** Embankment control stakes shall conform in type of material and dimensions to the requirements shown on the plans. The stakes and cross arms shall be painted white and the horizontal arm on each control stake shall have scale graduations in black for measuring movement.

#### **204.13 Construction Requirements.**

**204.13.1** The stakes shall be set firmly in a vertical position by placing in predrilled holes and backfilling with a lean concrete mixture. Stakes shall be set at locations shown on the plans or as directed by the engineer and shall be set in straight lines or straight line segments. A straight line segment shall consist of not less than three vertical stakes aligned so as to form, with the horizontal cross arms, planes of visual reference for detection of earth movement. Cross arms need not be at constant elevation but shall be aligned along a constant line of sight plane. Adjacent or intersecting straight line segments may have common stakes.

**204.13.2** Unless located on an embankment slope or berm, control stakes shall be placed prior to construction of the adjacent embankment except that, with the engineer's approval, embankment not to exceed 5 feet (1.5 m) high may be placed prior to installation of the stakes, if deemed necessary to minimize disturbance from equipment working in close proximity to the stakes.

**204.13.3** It shall be the contractor's responsibility to maintain and protect the stakes from damage and to notify the engineer if movement is detected. Stakes damaged or misaligned by accident due to the contractor's negligence shall be replaced or realigned at the direction of the engineer, at the contractor's expense.

**204.13.4** If movement is detected in the embankment control stakes, the engineer may require that embankment construction be discontinued for a period not to exceed 10 days until corrective measures can be determined.

**204.14 Basis of Payment.** Accepted embankment control stakes, complete in place, will be paid for at the contract unit price. No direct payment will be made for any devices required to protect the stakes nor for any delays resulting as a consequence of their use.

#### SECTION 204.20 SETTLEMENT GAUGES

**204.21 Description.** Settlement gauges shall consist of pipe gauges installed for the purpose of obtaining foundation settlement data during the placing, and following completion, of embankment and surcharge construction. An estimated number of settlement gauges will be indicated in the contract; however, the exact number and location will be determined by the engineer.

**204.22 Material.** A settlement gauge shall consist of the following:



(a) A steel plate, with a galvanized riser pipe attached perpendicular to the plate at its center by a continuous weld.

(b) Lengths, to be approved by the engineer, of 3/4-inch (19 mm) threaded galvanized riser pipe and couplings.

(c) Lengths, to be approved by the engineer, of galvanized 1 1/2-inch (38 mm) threaded pipe and couplings to act as a cover or guard for the riser pipe.

#### **204.23 Construction Requirements.**

**204.23.1** The first section of the 3/4-inch (19 mm) pipe shall be welded to the plate. The distance from the top of plate to the top of pipe will be accurately measured and recorded by the engineer.

**204.23.2** An excavation, slightly larger than the plate, shall be made to a depth approximately 18 inches (450 mm) below the natural ground surface. Care shall be exercised during excavation to ensure that the bottom of the pit is level and that the material at this location is undisturbed. The pit bottom shall be covered with a layer of portland cement mortar, approximately 3 inches (75 mm) thick, and the plate bedded therein in such position that the riser pipe is vertical. After the mortar has set, the cover pipe, cut approximately 6 inches (150 mm) shorter, shall be slipped over and centered around the riser pipe. The backfill shall then be placed in 6-inch (150 mm) layers and thoroughly compacted. The contractor shall notify the engineer when the installation is complete. No embankment shall be placed around the gauge until the elevation of the top of the riser has been determined by the engineer.

**204.23.3** Embankment material in the immediate vicinity of the settlement gauge pipe shall be placed and compacted in accordance with the requirements of [Sec 726.6.1](#). When the elevation of the embankment reaches a level approximately one foot (300 mm) below the top of the cover pipe, the engineer shall be notified and the next section of riser pipe and cover pipe shall be installed in the engineer's presence. As the height of the embankment increases, this procedure shall be repeated until the embankment and surcharge is completed, and the pipe sections, both riser and cover, extend approximately 2 feet (600 mm) above the surface of the completed embankment and surcharge.

**204.23.4** All necessary precautions shall be taken to keep the alignment of the riser pipe and cover pipe maintained in a vertical position at all times. The contractor shall operate equipment so that the settlement gauges are not damaged or displaced. Protective barriers shall be erected when so directed by the engineer. Settlement gauges shall be maintained in a satisfactory operating condition until after placing of the embankment and surcharge and until, in the judgment of the engineer, the settlement readings are no longer necessary. Any gauges that are damaged shall be repaired or replaced by and at the contractor's expense.

**204.23.5** The engineer will obtain and record all measurements and elevations necessary for accurate determination of settlement data during and after completion of embankment and surcharge.

**204.24 Basis of Payment.** Accepted settlement gauges, complete in place, will be paid for at the contract unit price. No direct payment will be made for any devices required to protect the gauges.

## **SECTION 204.30 PORE PRESSURE MEASUREMENT DEVICES**

**204.31 Description.** This work shall consist of placing and maintaining pore pressure measurement devices as shown on the plans for obtaining foundation pore pressure measurements during the placement of embankment. Pore pressure measurement devices, locations, elevations and limits of embankment subject to control by each device will be shown on the plans.

**204.32 Equipment.** Pore pressure measuring devices shall consist of the following types:

(a) Type A. This device consists of a pneumatic transducer sealed within a sand chamber which is set into the foundation to the specified elevations. The transducer is attached to jacketed plastic tubing which extends to the surface for connection to pressurizing and gauging equipment.

(b) Type B. This device consists of a 1/2-inch (13 mm) PVC standpipe extending to the surface of the embankment from a sand chamber set into the foundation to the specified elevations.

**204.32.1** The pneumatic transducer, jacketed tubing, and necessary pressurizing and gauging equipment for Type A installations will be furnished by the Commission without cost to the contractor upon two weeks written notice preceding the date of installation. The balance of the material for the Type A installation shall be furnished by the contractor. All material for the Type B installation shall be furnished by the contractor, except an electrical sounding device.

### **204.33 Construction Requirements.**

**204.33.1** The contractor shall be responsible for making the installation, for furnishing all incidental material, for providing all necessary protection of the installation, and for replacement in the event of damage, including cost of any replacement equipment furnished by the Commission. In the event of damage to the installation, the engineer may require suspension of embankment construction in the controlled area until the contractor has restored the installation to satisfactory working order. Installation of the pore pressure measurement device shall precede placement of any embankment by at least two weeks to allow time for testing of the completed installation and replacement in the event of malfunction. No embankment may be placed until the installation is complete and tested to the satisfaction of the engineer.

**204.33.2** A hole of not less than 5 inches (125 mm), nor more than 8 inches (200 mm) in diameter, shall be drilled to elevation B as defined in the plans. If necessary, casing shall be used to prevent sloughing of material from the walls of the hole and contamination of the walls or bottom of the hole by sloughed material. Casing shall be no smaller in its outer diameter than the diameter of the hole and shall have no externally coupled joints in the bottom 10 feet (3 m).

**204.33.3** If casing is required, the hole shall be washed to the bottom with clean water circulated through the bit until the discharge is clear. Clean sand shall then be poured into the hole to the approximate depth shown on the plans. The assembled pore pressure measurement device shall then be lowered to its indicated position with care to avoid contamination with soil from the side of the hole and additional sand shall be placed around it to elevation A as shown on the plans. During these steps, any casing shall be pulled ahead of the backfill in increments of 6 inches to 24 inches (150 to 600 mm) as necessary to prevent collapse or

sloughing of the hole. The hole shall be maintained full of clean water during these steps to at least the elevation of the top of the sand chamber. Every effort shall be made to prevent the creation of pockets of soil, air or voids in the sand backfill.

**204.33.4** After sand is placed to the specified elevation, the hole shall be backfilled with wetted, plastic bentonite clay as the casing is withdrawn, for not less than 4 feet (1.2 m) above the top of the sand filled chamber. If necessary, the clay shall be worked by hand into plastic balls to be dropped into the hole and tamped into a coherent mass. An acceptable alternate is the use of preformed dry bentonite pellets. In dry installation, dry granular bentonite may be tamped in place. The remainder of the hole shall be filled with a thick slurry of bentonite.

**204.33.5** At natural ground level, or as otherwise directed by the engineer, four layers of 3/4-inch (19 mm) exterior grade plywood, 4 x 4 feet (1200 x 1200 mm), nailed and clinched together with rustproof nails, and with a 3-inch (75 mm) diameter hole cut at the center shall be centered over the installation after the ground is smoothed and leveled with sand. A closet flange or other suitable receptacle shall be securely fastened to the plywood over the 3-inch (75 mm) diameter hole so as to securely receive a 5-foot (1.5 m) length of 3-inch (75 mm) iron or steel casing. Earth or sand shall be compacted about the casing in 6-inch (150 mm) lifts with care to avoid misalignment after the engineer has established the elevation of the plywood slab and the top of the casing.

**204.33.6** Upon completion, each installation shall be tested. Type A installations shall be tested in accordance with recommendations of the transducer manufacturer. Type B installations shall be tested by dropping a weighted line through the standpipe to check for possible obstructions. The standpipe shall then be filled with water and periodic readings made of the water level in the standpipe until the level of natural ground water is reached. If less than a 70 percent drop in head is experienced in the first 24 hours, the standpipe shall be flushed and retested. Records of rate of head loss shall be kept for subsequent evaluation of possible time lags in response of water levels to embankment placement.

**204.33.7** The engineer may require the installation of additional pore pressure measurement devices, at the contract unit price, within any area subject to control by such devices, at any time during the construction of the embankment. The engineer will determine the type of device, location and elevation of additional installations. Any such additional pore pressure measurement devices shall govern the rate of construction in the same manner as the original devices. The reference pressure levels for additional devices shall be either that of the original devices or as determined from boreholes located outside the loaded area, as directed by the engineer.

#### **204.34 Pore Pressure Measurements and Records.**

**204.34.1** The engineer will make and record all observations and measurements required to determine natural ground water pressures and pore water pressures induced by embankment construction. The pressure of the natural ground water existing at the time of installation and prior to placement of any embankment will be used as a reference to determine pore pressures induced by subsequent embankment placement. However, the engineer may subsequently require borings outside the loaded area to facilitate observations to determine if the natural ground water table has lowered due to seasonal or climatic variations. Such observations may be used to lower, but not raise, the initial reference ground water pressure.

**204.34.2** The engineer will make all records of ground water and pore water pressures readily available to the contractor for guidance in the planning of the contractor's work.

**204.34.3** If foundation pore pressure, in excess of pressure from the natural water table, equals or exceeds 35 percent of the unit pressure of the embankment in place over the installation at any time, placement of embankment shall be immediately suspended. Construction shall not resume until such excess pressure declines to 25 percent of embankment pressure, unless otherwise authorized by the engineer.

**204.34.4** After the embankment reaches an elevation equal to 60 percent of the maximum height, the contractor shall control the rate of construction in such a manner that foundation pore pressure, in excess of pressure from the natural water table, will not exceed 35 percent of the unit pressure of the embankment in place over the installation at any time. [An example of pressure relationships follows: Soil embankment with an average wet density of 125 pounds per cubic foot ( $2000 \text{ kg/m}^3$ ) is equal to twice the unit weight (mass) of water. A foot (0.3 meter) of such embankment thus has a potential to create, at most, 2 feet (0.6 meter) of water rise in a standpipe, or a 0.87 pound per square inch (5.9 kPA) increase in a Type A installation. The contractor may thus anticipate the maximum possible effect of any load to be added.] The contractor is cautioned that Type B installations are prone to some time lag in rate of response to a pressure increment. Records of pore pressure response during placement of the first 60 percent of embankment height shall be examined for evidence of such lag. The time required for dissipation of head during testing will also be indicative of the rate of response.

**204.34.5** When embankment has advanced to within approximately one foot (300 mm) of the top of the casing, the casing and the 1/2-inch (13 mm) PVC pipe for the Type B installations, shall be advanced in 5-foot (1.5 m) increments. No extension shall be made without the engineer's approval. PVC pipe extensions shall be made using solvent welded couplings exercising care to make smooth, squared cuts with all burrs removed, in accordance with recommendations of the pipe and solvent cement manufacturers. Pneumatic tubing leads used with Type A installations shall be long enough to permit extension, without connections, to the top of the embankment or surcharge. Excess tubing shall be stored in a steel container attached to the last casing extension as shown on the plans.

**204.35 Settlement Records.** The engineer will make and record all measurements and elevations necessary, including elevations of the plywood plate and all casing extensions, for use in establishing a settlement record at the site of the pore pressure measurement device. The 3-inch (75 mm) outer steel casing will be used for this purpose. Care shall be taken to ensure the tightest possible coupling connections, using pipe wrenches, without rotating the bottom pipe. Settlement records obtained in this manner may be used to satisfy such settlement rate requirements as may be outlined in the contract.

**204.36 Basis of Payment.**

**204.36.1** The contract unit price shall include acceptance by the contractor of the possible restraints inherent in the use of these devices upon the rate of construction. No additional compensation will be made for any costs incurred as a result of compliance with this requirement.

**204.36.2** Accepted pore pressure measurement devices, complete in place, will be paid for at the contract unit price per each.

## SECTION 205

### OVERHAUL

**205.1 Description.** This work shall consist of authorized hauling in excess of the free-haul distance. Free-haul distance is the specified distance that excavated material shall be hauled without additional compensation. The free-haul distance is 2000 feet (600 m) for Overhaul (Station).

**205.1.1** If the contract documents show no pay item for overhaul, then no direct payment will be made for such work, even if the plans show hauling beyond the free-haul distance.

**205.1.2** Contract quantities of overhaul will be the basis of payment for all overhaul in any balance, unless the engineer:

(a) Authorizes a change in grade resulting in a net average change in elevations of more than 6 inches (150 mm) from the plan grade line in any balance.

(b) Authorizes substantial change in the typical section from the section shown on the plans.

(c) Requires changes in plan locations for sources of borrow.

(d) Determines that the actual borrow quantities differ from the plan quantities in balances where overhaul has been computed on borrow quantities only.

(e) Determines that there is a substantial error in the contract quantity.

**205.1.3** In cases where the condition described as (c) or (e) occurs, the quantity of overhaul for the balances so affected will be computed. In cases where one or more of the conditions described as (a), (b) and (d) occurs, the pay quantity of overhaul will be increased or decreased from the contract quantity in the ratio that the contract quantity of excavation bears to the actual quantity in the affected balance limits.

**205.1.4** Plan location will be used to compute overhaul if a change in location of borrow or waste areas as proposed by the contractor has been approved.

**205.2 Method of Measurement.** The limit of free-haul will be determined from a mass diagram by fixing on the volume curve, two points, one on each side of the neutral grade point, one in excavation and the other in embankment, such that the distance between them equals the free-haul distance, and the included quantities of excavation and embankment are in balance. All material within the free-haul limit will be eliminated from further consideration. The distance between the center of gravity of the remaining mass of excavation and the remaining mass of embankment minus the free-haul distance will be the overhaul distance.

**205.2.1** The overhaul distance for Overhaul (Station) will be measured to the nearest full station, 100 feet (made to the nearest 1/10 station, 100 m). The quantity of overhaul will be the product of the overhaul distance multiplied by the quantity in cubic yards (cubic meters) of material hauled in excess of the free-haul distance, and will be made in units of station yards (made in units to the nearest 0.1 station m<sup>3</sup>).

**205.2.2** The overhaul distance for material obtained from borrow areas or disposed of in waste areas and hauled over the shortest practicable route will be one-half the round-trip distance made by the equipment less the free-haul.

**205.2.3** Analytical methods may be used for computing overhaul in lieu of the mass diagram method described herein.

**205.3 Basis of Payment.** The quantity of overhaul measured as provided above will be paid for at the contract unit price. Payment will not be made for overhaul of material secured from excavation made because of the failure of the contractor to observe the balance points established on the plans or as staked, unless such deviation was directed by the engineer.

## SECTION 206

### EXCAVATION FOR STRUCTURES

#### **206.1 Description.**

**206.1.1** This work shall consist of the necessary excavating for the foundations of all structures, the removing and disposing of all excavated material, the backfilling around the completed structures and all related work.

**206.1.2** No direct payment will be made for removing existing structures within the limits of excavation for structures. However, existing headwalls or culvert concrete to be removed will be paid for as removal of improvements for roadway culverts or partial removal of culvert concrete for bridge culverts. All removal work which might endanger the new structure shall be completed before any work on the new structure is started. Partial removals of any structure or adjustments of any utility shall be made with care to preserve the value of the retained portions. Work around any live utility shall be done in such manner that uninterrupted service is maintained.

**206.1.3** Excavated material which is unsuitable for backfill and embankments, and excess material not required for either, shall be disposed of. It shall not be dumped into the channel of a stream without the written authorization of the engineer.

**206.2 Depth of Excavation.** The elevation of the bottoms of footings as shown on the plans shall be considered an approximate elevation, and the engineer by written order may make such changes in plan elevations and dimensions of footings as may be necessary to secure a satisfactory foundation.

**206.3 Foundation Stabilization and Tests.** The contractor shall furnish and place sand, rock, gravel or other suitable backfill material to replace unsuitable material encountered below the foundation elevation of the structures. The contractor shall stabilize suitable foundation material or form the bottom of pile footings if necessary to obtain a stable foundation. The contractor shall furnish assistance in driving sounding rods or drilling test holes to permit an adequate inspection of the foundation. The depth of the excavation, the character of the material and the condition of the foundation shall be approved by the engineer before any concrete is placed in the footing.

#### **206.4 Construction Requirements.**

**206.4.1** Methods shall be used in excavating for foundations of structures that will ensure maintaining the stability of the material adjacent to the excavation. Sheet piling, cribbing, timbering or bracing shall be placed by the contractor where indicated on the plans and wherever considered necessary. The contractor will be held responsible for the adequacy of all sheet piling, cribbing, timbering or bracing used.

**206.4.2** Foundations for structures and retaining walls shall be free of loose, shelly or disintegrated rock, and the footing shall be placed on undisturbed material. Footings shall be keyed not less than 6 inches (150 mm) into hard, solid rock and not less than 18 inches (450 mm) into soft rock or shale or other suitable material specified for spread footings. Excavation in rock or shale for the key shall be made as near as practicable to the size of the footing, or of the key as shown on the plans. When placing the footing, the key portion shall be cast against the vertical, undisturbed face of the rock or shale. If side forms are necessary

for footings, they shall be removed approximately 24 hours after placing the concrete, and the excavation immediately backfilled to the top of the footing. All cavities or crevices shall be cleaned out and filled with concrete in accordance with [Sec 703.3.12.8](#), or spanned with a reinforced concrete beam, as directed by the engineer.

**206.4.3** Care shall be taken to avoid disturbing the material below the bottom of the footings where the structure is founded on material other than rock, and final removal to grade shall not be made until just prior to placing concrete. Where foundation piles are required, the excavation of each pit shall be completed before the piles are driven, and after the driving is completed all loose and displaced material shall be removed.

**206.4.4** If rock is encountered under a portion of the bottom slab of a concrete box-type structure, the rock shall be removed to at least 6 inches (150 mm) below the bottom of the slab and curtain walls, and backfilled with material similar to that under the remainder of the structure.

**206.4.5** Concrete footings for structures shall be placed on reasonably dry foundation material. The contractor shall perform all draining, bailing or pumping operations, drive any sheeting, and construct any cofferdams or cribs necessary to obtain this condition. Pumping from the interior of any foundation enclosure shall be done in a manner to preclude the possibility of the movement of water, or other fluids or semi-fluids, through any fresh concrete. If necessary, the footing form shall be made watertight and shall be sealed around the bottom, and all pumping done between the footing form and the wall of the enclosure.

**206.4.6** All holes, pits or sumps resulting from excavating operations shall be kept drained or pumped out until the completion of the work. No ponding of water around footings on other than rock will be permitted.

**206.4.7 Cofferdams.** Cofferdams shall, in general, be carried well below the bottom of the footings, and shall be well braced and as watertight as practicable. The interior dimensions of cofferdams shall provide sufficient clearance for the construction of forms and ample room for a sump and for pumping outside the footing forms. Cofferdams which have been tilted or moved laterally during the process of sinking shall be corrected to provide the necessary clearance. They shall be constructed to protect the work against damage from sudden rising of the stream and to prevent damage to the foundation by erosion. Cofferdams, with all sheeting and bracing, shall be removed after the completion of the substructure unit, unless specific authority is given for them to be left in place. The contractor, upon request, shall submit drawings showing the contractor's proposed method of cofferdam construction and other details open to the contractor's choice or not fully shown on the plans.

**206.4.8 Seal Courses.** Seal courses will be required if indicated on the plans or if conditions are encountered which, in the judgment of the engineer, render it impracticable to dewater the foundation area. The dimensions of the seal course shall be adequate to seal the foundation area. Pumping will not be permitted while excavating, driving piling or placing the seal course, and not until, by determination of the engineer, the seal course has attained sufficient strength to withstand the hydrostatic pressure. If seal courses are shown on the plans, and it develops that the footings may be satisfactorily placed without sealing, the contractor will be required to dewater any completed excavation for investigation purposes. Seal courses, other than those on the plans, will not be authorized or permitted except for extreme cases where it is impracticable to dewater the footing area by other means, and then only with the written permission of the engineer.

**206.4.9 Backfill.** Backfill material shall be of an acceptable quality and shall be free from large or frozen lumps, wood or other extraneous material. All spaces excavated and not



occupied by the new structure or by porous backfill shall be refilled with earth to the original ground surface or to the finished ground lines shown on the plans. All backfill shall be thoroughly compacted and its top surface neatly graded. The backfill at end bents, walls or other units which fall within the limits of the roadbed shall be placed in successive 6-inch (150 mm) layers and compacted to the same density required for the adjacent roadbed. Special precaution shall be taken to prevent any wedging action against the masonry. The slope bounding the excavation, if steeper than six horizontal to one vertical (one vertical to six horizontal), shall be stepped or serrated. Backfill placed around culverts and piers shall be kept at approximately the same elevation on opposing sides. Drains consisting of 5 cubic feet (0.15 m<sup>3</sup>) of coarse aggregate shall be placed at weep holes except where porous backfill is required. Backfill material shall not be placed against end bents of bridges, sides of box culverts or back of retaining walls until the concrete has attained the strength specified in [Sec 703.3.10](#). Backfill material shall not be placed higher behind than in front of end bents until the superstructure is in place. Until the grade is in place, drainage shall be maintained away from the end bent backwall by constructing a six horizontal to one vertical (one vertical to six horizontal) or steeper slope away from the backwall for a minimum distance of 3 feet (1 m) and providing a lateral path for all water to flow off the roadbed section.

**206.4.10 Porous Backfill.** Porous backfill meeting the requirements of [Sec 1009](#) shall be placed in back of abutments, wings and retaining walls where specified and shown on the plans. It shall be 18 inches (450 mm) thick and shall extend from the bottom of weep holes or other drainage devices to within 2 feet (600 mm) of the finished ground line. The remaining 2 feet (600 mm) shall be backfilled with earth. Porous backfill shall be so placed and consolidated in successive 12-inch (300 mm) layers that it will not become mixed with other backfill material.

**206.4.11 Flowable Backfill.** Flowable backfill will be required when indicated on the plans. The contractor may, with the approval of the engineer, use flowable backfill as an alternate to compacted backfill for structures, pipes or utility cuts. Flowable backfill intended for any other use by the contractor shall also be approved by the engineer. Flowable backfill shall not be used to surround drainage systems such as vertical drains or edge drains. Flowable backfill shall meet the requirements of [Sec 621](#).

**206.4.12 Excavation Classification.** Unless otherwise shown on the plans, excavation for structures will be classified as Class 1 Excavation, Class 1 Excavation in Rock, Class 2 Excavation, Class 2 Excavation in Rock, Class 3 Excavation or Class 3 Excavation in Rock. In general, Class 1 Excavation and Class 2 Excavation will apply to excavation for bridges and large retaining walls. Class 3 Excavation will apply to excavation for culverts, concrete box-type structures classed as bridges, sewers, small retaining walls and other miscellaneous structures. Class 1 Excavation will include all excavation above a specified elevation indicated on the plans while Class 2 Excavation will include all excavation below this specified elevation. The classification of excavation for all structures will be shown on the plans. Any material excavated in cleaning out culverts which are used in place will be paid for at the contract price per each structure. However, only the initial excavation will be paid for, and any subsequent cleaning required prior to final acceptance shall be done at the contractor's expense.

## **206.5 Method of Measurement.**

**206.5.1** Measurement of Class 1 and Class 2 Excavation will be made to the nearest 1/2 cubic yard (0.5 m<sup>3</sup>) for each structure of that volume of material actually removed from within the limits herein established. The volume measured will be limited by vertical planes 18 inches (450 mm) outside of and parallel with the neat lines of footings, tie beams or overhangs of structures classed as bridges or retaining walls. The upper limits of the volume measured will

be the existing ground line or the lower limits of the roadway, drainage or channel excavation, including any allowable overbreak, whichever is lower. Where roadway spill fills are required to be placed and compacted before driving piles or before constructing bridge substructure units, any required additional excavation for the substructure units will be measured from the spill slope. For stream crossings, the measured volume will not include water, but will include mud, muck and other semi-solids. The lower limits of the volume measured will be the bottom of the footings, bottom of seal courses, or 18 inches (450 mm) below the bottom of tie beams and overhangs. For timber bents, the excavation will be measured within the horizontal limits shown on the plans to the bottom of the backing supports for end bents, and to the bottom of the sway bracing for intermediate bents.

**206.5.1.1** Excavation for columns above pedestal piles will be Class 1 Excavation with measurement being made of the volume of material actually removed above top of pedestal. The volume measured will not exceed that of a cylinder having a diameter 36 inches (900 mm) greater than that of the column above the pedestal. No measurement will be made of the material excavated for the pedestal below the bottom of the column.

**206.5.2** Measurement of Class 3 Excavation will be made to the nearest cubic yard (cubic meter) for each structure of that volume of material actually removed from within the area bounded by vertical planes 18 inches (450 mm) outside of the outer walls of box culverts with bottom slabs or the sides of pipe culverts except as modified for vitrified clay pipe culverts in [Sec 726.8.2\(a\)](#) and except the volume of headwall and culvert concrete removals included in the contract for direct payment. The upper limits of the volume measured will be the existing ground line, or the lower limits of the roadway excavation, whichever is lower. Class 3 Excavation under embankments and in channel changes will be measured from the original ground surface unless otherwise designated on the plans. For box culverts without bottom slabs, measurement will be made as above except no material below plan flow line will be included which is outside of the area bounded by vertical planes 18 inches (450 mm) each side of and parallel with the neat lines of the walls or footings.

**206.5.2.1** Final measurement of Class 3 Excavation for box culverts with a span of 6 feet (2 m) or less, pipe culverts, sewers and miscellaneous small structures will not be made unless there is an authorized change from plan location resulting in a different quantity or there is an authorized change averaging more than 6 inches (150 mm) in the foundation elevation. If a revision is made or an appreciable error is found in the contract quantity, the revision or correction will be computed and added to or deducted from the contract quantity. Measurement of Class 3 Excavation will be made for authorized excavation necessary to locate existing utilities requiring reconstruction work.

**206.5.3** Where concrete in footings or walls is cast against the vertical faces of the excavation, the neat lines of the concrete footings will be considered the limits of excavation for that depth in which the concrete is in contact with the excavation, and no measurement will be made of any excavation or overbreak beyond the neat footing lines.

**206.5.4** The volume of porous backfill will be computed to the nearest cubic yard (cubic meter) at each structure from dimensions on the plans. Any porous backfill material placed outside the neat lines shown on the plans shall be placed at the contractor's expense. Final measurement of the porous backfill will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

## **206.6 Basis of Payment.**

**206.6.1** Payment for additional Class 1 and Class 2 Excavation required to carry footings a maximum of 8 feet (2.5 m) below elevations shown on the plans will be made at 125 percent of the contract unit price for that additional excavation within the limits of Class 1, and at 150 percent of the contract unit price for that additional excavation within the limits of Class 2 Excavation. Additional excavation required to carry footings a depth of more than 8 feet (2.5 m) below plan elevations will be considered changes in the work, and will be paid for as provided in [Sec 104.3](#).

**206.6.2** Payment for drilling test holes for foundation tests will be made at the rate of \$6.00 per foot (\$19.70/m) of hole drilled.

**206.6.3** Payment will not be made for removal or replacement of foundation material which became unsuitable because of improper methods of construction by the contractor. Payment for removal of inherently unsound material for foundation stabilization will be made at the contract unit price for excavation for structures. No payment will be made for any costs involved in replacing the volume below grade, except that the contractor will be reimbursed for the delivered material cost if a granular type material is specified by the engineer.

**206.6.3.1** If Class C Excavation material, as defined by [Sec 203](#), is encountered in Class 1 Excavation, and no pay item for Class 1 Excavation in Rock is included in the contract, payment for that material will be made at \$100.00 per cubic yard (\$130.00/m<sup>3</sup>). Increased payment will be made only in cases where the presence of Class C Excavation material was not identified in information available under [Sec 102.5](#) pertaining to soundings for spread footings.

**206.6.3.2** If Class C Excavation material, as defined by [Sec 203](#), is encountered in Class 2 Excavation and no pay item for Class 2 Excavation in Rock is included in the contract, payment for that material will be made at \$150.00 per cubic yard (\$195.00/m<sup>3</sup>).

**206.6.3.3** If Class C Excavation material, as defined by [Sec 203](#), is encountered in Class 3 Excavation and no pay item for Class 3 Excavation in Rock is included in the contract, payment for that material will be made at \$65.00 per cubic yard (\$85.00/m<sup>3</sup>).

**206.6.4** No direct payment will be made for placing porous backfill at weepholes, as required by [Sec 206.4.10](#), or for backfilling the structure.

**206.6.5** The accepted quantities of excavation for structures and porous backfill will be paid for at the unit price for each of the pay items included in the contract.

## SECTION 207

### LINEAR GRADING

**207.1 Description.** This work shall consist of grading work necessary to bring the roadway to the required grade and cross section within reasonable tolerances. It shall also include the following:

- (a) Construction of all inlet and outlet ditches and ditch blocks within the linear grading limits unless otherwise provided for in the contract.
- (b) Construction of entrances and approaches.
- (c) Breaking up and satisfactory removal or incorporation into the roadway of all gravel, macadam or bituminous surfaces.
- (d) Compaction of the roadway subgrade within linear grading limits.

All linear grading will be classified as hereafter described.

**207.1.1** Linear Grading, Class 1, shall consist of grading where the topography is such that the excavation necessary to bring the roadway to the designated cross section will approximately make the nearby embankments with a minimum of drifting or hauling, and where it will not be necessary to control the finished grade line for purposes other than to obtain minimum cover over culverts.

**207.1.2** Linear Grading, Class 2, shall consist of grading where it is necessary to excavate and haul material to bring the roadway to the desired grade and may involve work on high banks and side hills.

**207.1.3** The class of linear grading designated on the plans will apply only to those sections which have been specifically indicated as such on the plans and will not be subject to change during construction.

#### **207.2 Construction Requirements.**

**207.2.1** The roadway shall be brought to the required grade and cross section within reasonable tolerances by backsloping, ditching, removing stone and boulders from the roadbed surface, or any other work necessary, including drifting and hauling of any excavated material. A reasonable tolerance in alignment means a maximum gradual deviation of 2 feet (600 mm), free of sharp breaks, to take advantage of favorable topography. Gradual deviation in alignment will also be permitted, if necessary to center an existing drainage structure that is to be used in place. A reasonable tolerance in grade means a final grade that is uniform in appearance, free of sharp breaks or humps, and within 6 inches (150 mm) of plan grade.

**207.2.2** Stumps, roots, rubbish or any other deleterious material shall not be placed in embankments. Where an embankment less than 2 feet (600 mm) high is to be constructed, all vegetative matter shall be cut and removed from the surface upon which the embankment is to be placed. The cut-over surface shall be thoroughly broken. All ditches including inlet and outlet ditches shall be cut to grades that will properly drain. The required cross section for inlet and outlet ditches leading to or from structures shall be of a width not less than the width of the floor or the diameter of the structure being served. Finishing operations shall continue

until the roadbed is free from sharp breaks in alignment and grade, and until it has been shaped to the required cross section. Material considered unsuitable for the subgrade shall be disposed of on nearby slopes or as otherwise directed by the engineer.

**207.2.3** If obliteration of old roads is designated in the contract to be performed on a linear grading basis, such obliteration shall include all grading operations necessary to fill the ditches and blend the old road with the natural ground to provide a pleasing appearance.

**207.2.4** Any subgrade upon which a paved surface is to be placed shall be compacted in accordance with [Sec 203](#).

**207.3 Method of Measurement.** Measurement of Linear Grading, Class 1 and Class 2, will be made to the nearest 1/10 station (0.005 station).

**207.3.1** Unless otherwise provided in the contract, measurement and payment for entrances and approaches will be made as Linear Grading, Class 1. Entrances and approaches will be measured along the centerline of each facility, regardless of the width to be constructed, beginning at the shoulder line of the road that is being entered and extending to the point of zero cut or embankment of the entrance or approach. Measurements of 30 feet (10 m) or less will be compensated for at 3/10 station (0.01 station). Measurements in excess of 30 feet (10 m) will be made to the nearest 1/10 station (0.005 station).

**207.3.2** If material is encountered that may be classified as other than Class A Excavation as described in [Sec 203.1](#), the limits of Linear Grading will not be underrun but the material classified as other than Class A Excavation will be measured and paid for on a yardage (cubic meter) basis in accordance with [Sec 203.7](#). If the contract does not contain a unit price for Class A Excavation and if Class C Excavation is encountered, payment for Class C Excavation will be made at a unit price of \$5.00 per cubic yard (\$6.50/m<sup>3</sup>) regardless of quantity, unless the project is let on an unclassified basis. Where undergrading is necessary, backfilling of the undergraded area will be considered as a part of the linear grading operation.

**207.4 Basis of Payment.** The accepted quantities of linear grading will be paid for at the unit price for each of the pay items included in the contract, and will be considered as full compensation for all equipment, labor, material or other construction involved in completing this work.

## SECTION 208

### INTERCEPTION DITCH

**208.1 Description.** This work shall consist of all work necessary to construct an interception ditch or levee, or both, in accordance with the typical sections at locations shown on the plans, or as directed by the engineer.

**208.2 Construction Requirements.** Interception ditches shall be constructed in a manner to provide a profile free from sharp breaks or irregularities. Hand finishing will not be required but the work shall be finished to a reasonably smooth and uniform surface. Loose rock shall be removed from the finished surfaces.

**208.3 Method of Measurement.** Measurement will be made to the nearest 10 feet (5 m) along the flow line of the ditch for each increment and totaled to the nearest 100 feet (25 m) for the sum of all increments.

**208.4 Basis of Payment.** The accepted quantity of interception ditch will be paid for at the contract unit price.

## SECTION 209

### SUBGRADE PREPARATION

**209.1 Description.** This work shall consist of preparing the subgrade upon which a base course is to be constructed or a surfacing placed. After a base course has been constructed, the top of the completed base course will be considered the subgrade for the next operation. In surfacing contracts involving only incidental grading, the contractor shall complete Subgrade Compaction in accordance with [Sec 210](#) before proceeding with this work.

**209.2 Equipment.** A self-propelled steel wheel roller weighing not less than 10 tons (9 Mg) shall be used in preparing any subgrade for flexible type surfacing and weighing not less than 5 tons (4.5 Mg) in preparing any subgrade for portland cement concrete base course or pavement.

**209.3 Construction Requirements.** The subgrade shall be substantially uniform in density throughout its entire width. It shall conform to the lines, grades and typical cross sections shown on the plans, or as established by the engineer. The subgrade shall be constructed to drain surface water to the side ditches and all ditches shall be kept open by the contractor. Where hauling results in ruts or other objectionable irregularities, the contractor shall reshape and reroll the subgrade before the base or surfacing is placed. If an old traveled roadway comprises any part of the roadbed, the contractor shall loosen the compacted portions to a depth of at least 6 inches (150 mm) and shall reshape the roadbed.

**209.3.1** All subgrades, except those for aggregate type surfacing, shall be rolled. The subgrades shall be checked after rolling and, if not at the proper elevation at all points, sufficient material shall be removed or added and compacted to bring all portions of the subgrade to the required elevation and density. The moisture content of the top 6 inches (150 mm) of the finished subgrade at the time the base is placed, or at the time the pavement is placed if no base is provided under the pavement, shall be not less than the minimum specified for compacting in [Sec 203](#). If the moisture content has not been maintained, the subgrade shall be scarified, wet to the required moisture content and compacted. A roughly compensating maximum deviation of 1/2 inch (13 mm), plus or minus, from the required elevation will be permitted on the surface of the finished subgrade.

**209.3.2** Prior to laying base or setting paving forms, the subgrade shall conform to the moisture and density requirements for compaction. Soft spots and unsuitable material shall be removed to a depth not to exceed 24 inches (600 mm) and backfilled with approved stable material.

**209.3.3** The subgrade for portland cement concrete pavement shall be compacted, and brought to true shape by an approved subgrade machine. Any material added shall be satisfactorily incorporated and compacted. Before the concrete is placed, a true subgrade shall be shaped by an approved subgrade planer rolling on the forms and any resulting loose material on the subgrade behind the planer shall be recompact with the 5-ton (4.5 Mg) steel wheel roller. The planer shall be adjustable to produce a subgrade of the exact elevation and cross section. After all grading or planing operations have been completed, and immediately before the concrete is placed, the subgrade shall be checked with an approved heavy metal template which shall be rolled on the forms. Scratch templates with spikes or teeth will not be permitted. A taut line across the top of side forms and a ruler may be used in lieu of a template for checking the subgrade on irregular areas or variable widths. Extreme care shall

be taken in forming the crown and shaping the subgrade to ensure that the specified thickness of concrete will be attained in the finished pavement.

**209.3.3.1** The finished subgrade at the time of paving shall be moist, but sufficiently firm to resist rutting or deforming under construction traffic.

**209.3.4** No direct payment will be made for subgrade preparation.



## SECTION 210

### SUBGRADE COMPACTION

**210.1 Description.** This work shall consist of compacting the earth subgrade on the roadbed of a previously graded roadway. This work shall be performed prior to any work under [Sec 209](#).

**210.1.1** The contractor shall perform this work on the subgrade at all locations specified by the engineer. Tentative locations of subgrade compaction will be shown on the plans, but the engineer will specify all locations and depths of this work by written order. Any overrun, or partial or complete underrun, shall not be a basis for claim.

#### **210.2 Construction Requirements.**

**210.2.1** The subgrade for the full width of the roadbed shall be scarified to a depth of at least 6 inches (150 mm), and the scarified material brought to a uniform moisture content either by drying or by adding water, and manipulating with suitable equipment. At the contractor's option, the upper 6 inches (150 mm) of soil may be removed and replaced with satisfactory material, or removed and manipulated with suitable equipment before replacing. The material shall be compacted to produce a subgrade having a density not less than the density required and within the moisture contents specified under [Sec 203](#) by the use of approved equipment producing satisfactory results.

**210.2.2** If it is determined that the required subgrade density cannot be obtained by moisture control and compaction of the upper 6 inches (150 mm), the unsuitable material shall be excavated to a depth not to exceed 18 inches (450 mm), and replaced with satisfactory material compacted in layers not to exceed 6 inches (150 mm), except as otherwise permitted by the engineer. Each 6-inch (150 mm) layer shall be processed, wetted or dried as necessary, and compacted to the required density.

**210.2.3** If an unsatisfactory subgrade has developed through negligence on the part of the contractor, the contractor will be required to restore it to a satisfactory condition at the contractor's expense.

**210.3 Method of Measurement.** Measurement will be made to the nearest 1/10 station (5 m) along the centerline of each roadbed, regardless of width, for each depth of compaction authorized. For the purpose of measurement, a divided highway will be considered as having two roadbeds. Measurement of ramps will be made from or to a point opposite the intersection of the outer edge of the pavement on the thruway, or its widening, and the inner edge of the pavement on the ramp.

**210.4 Basis of Payment.** The accepted quantity of subgrade compaction, 6-inch (150 mm) depth, will be paid for at the contract unit price. Subgrade compaction to a depth of 12 inches, two 6-inch layers (depth of 300 mm, two 150 mm layers) will be paid for at the rate of two times the contract unit price for subgrade compaction, 6-inch (150 mm) depth. Subgrade compaction to a depth of 18 inches, three 6-inch layers (depth of 450 mm, three 150 mm layers) will be paid for at the rate of three times the contract unit price for subgrade compaction, 6-inch (150 mm) depth.

## SECTION 211

### SUBGRADE SCARIFYING

**211.1 Description.** This work shall consist of loosening the surface of the roadbed and removing all rocks larger than 4 inches (100 mm). Tentative locations of subgrade scarifying will be shown on the plans, but the engineer will specify all locations of this work by written order.

**211.2 Construction Requirements.** Where subgrade scarifying is specified by the engineer, the contractor shall perform all work necessary to loosen the surface of the roadbed over its full width to a depth of 6 inches (150 mm) below the finished grading section, and remove all rocks larger than 4 inches (100 mm). Oversize material shall be disposed of as directed by the engineer. After all of the oversize material has been removed, the roadbed shall be brought back to a satisfactory grade and cross section by the addition of extra material, if needed, without rocks that exceed 4 inches (100 mm).

**211.3 Method of Measurement.** Measurement will be made to the nearest 1/10 station (5 m) for each increment, and totaled to the nearest 1/2 station (25 m) for the sum of all the increments composing the measurement along the centerline of the roadbed, regardless of the width of subgrade scarifying performed.

**211.4 Basis of Payment.** The accepted quantity of subgrade scarifying will be paid for at the contract unit price.

## SECTION 212

### SUBGRADING AND SHOULDERING

#### 212.1 Description.

**212.1.1** Subgrading and Shouldering, Class 1, shall consist of preparing the earth subgrade for the surfacing and shoulders by fine-grading and shaping the existing roadbed of a previously graded roadway, and shaping fill slopes, inslopes and ditches as required to complete a finished roadway conforming to the typical section.

**212.1.2** Subgrading and Shouldering, Class 2, in addition to the above, shall include the construction and final shaping of earth shoulders.

#### 212.2 Construction Requirements.

**212.2.1** Subgrading and shouldering will normally be restricted to the roadway from ditch to ditch or to the roadbed and upper portions of fill slopes. All ditches shall be graded to drain. The median, if any, shall be shaped to conform to the typical section. No work will be required on backslopes except that necessary to blend the lower portion of the existing backslope with the regraded ditch. The work on fill slopes shall be confined to the upper 10 feet (3 m) of the slope, measured along the slope line. Minor drifting of excavated material to bring the subgrade, shoulders and ditches to proper grade and section is to be expected. Minor drifting shall be considered the moving of material that one 10-cubic yard (7.5 m<sup>3</sup>) scraper can shift without delay to normal subgrading operations.

**212.2.2** If the subgrade has less density than that required under [Sec 203.3](#), the engineer may order the item of Subgrade Compaction to be performed. When lack of satisfactory density results from improper maintenance by the contractor, the subgrade density shall be restored at the contractor's expense. Earth shoulders shall be constructed in accordance with the requirements of [Sec 203.2](#).

**212.2.3** Finishing of ditches, side slopes, cuts and fills shall be to a reasonably smooth and uniform surface that will merge with the adjacent slopes. Finishing by hand methods will not be required, except that all brush, weeds, excess mud and silt, or other debris shall be removed from all channels and culverts within the scope of the work in accordance with [Sec 104.11](#) even though such structures are used in place.

**212.2.4** Any additional material required to complete the subgrade or shoulders to proper grade and section shall be obtained from within the right of way limits as directed by the engineer. No direct payment will be made for minor drifting of excavated material or any additional material required, nor will overhaul be allowed for such operations. Excess excavation shall be used for widening shoulders on fill sections or wasted within the limits of the right of way as directed.

**212.2.5** The repair of major erosion beyond the limits as described in [Sec 212.2.1](#) will be paid for as provided in [Sec 104.3](#).

**212.3 Method of Measurement.** Measurement of Subgrading and Shouldering, Class 1 and Class 2, will be made to the nearest 1/10 station (5 m) along the centerline of each roadbed, regardless of width. For the purpose of measurement a divided highway will be considered as having two roadbeds. Measurement of ramps will be made from or to a point opposite the

intersection of the outer edge of the pavement on the thruway, or its widening, and the inner edge of the pavement on the ramp.

**212.3.1** Subgrading and Shouldering, Class 1 and Class 2, will apply only to those sections that have been specifically designated as such on the plans and the class will not be subject to change during construction.

**212.4 Basis of Payment.** The accepted quantity of subgrading and shouldering will be paid for at the unit price for each of the pay items included in the contract.

## SECTION 213

### SHAPING SHOULDERS

**213.1 Description.** This work shall consist of grading and shaping existing shoulders to conform to the typical sections shown in the contract.

**213.1.1** Shaping Shoulders, Class 1, is defined as shaping shoulders where, in general, the material required to bring the roadway to the designated cross section can be obtained or disposed of within the right of way limits as directed by the engineer.

**213.1.2** Shaping Shoulders, Class 2, is defined as shaping shoulders where it may be necessary to go outside the limits of the right of way for additional material to construct the shoulders to the designated cross section or where it may be necessary to dispose of waste material outside the limits of the right of way.

#### **213.2 Construction Requirements.**

**213.2.1** Shoulders shall be constructed of suitable material to the cross section shown on the typical section. Ditches shall be provided in cut sections as indicated on the plans. Such additional ditch work as is necessary to ensure proper drainage shall also be performed. Vegetation on existing shoulders and slopes shall be mowed or cut in areas of grading work, and such cuttings shall be disposed of prior to the placing of any shoulder material. Shoulder material shall be compacted by a roller weighing (having a mass of) not less than 5 tons (4.5 Mg). Finishing of shoulders and slopes, and ditches where necessary, shall be to a reasonably smooth and uniform surface. Only that work will be required on backslopes as is necessary to blend the lower portion of the existing backslopes with any regraded ditch. Finishing by hand methods will not be required.

**213.2.2** If additional material is required for shaping shoulders to the minimum width, it shall be obtained from the backslopes as directed by the engineer, or from borrow areas outside the limits of the right of way in areas provided by and at the contractor's expense. If excess excavation results, it shall be disposed of by uniformly widening shoulders on embankment sections, or wasted outside the limits of the right of way in areas provided by and at the contractor's expense. The contractor shall provide the engineer with an acceptable written agreement with any property owner from whose property additional material is to be obtained or on which excess excavation is to be disposed.

**213.2.3** A temporary shoulder having a minimum width of 2 feet (600 mm) shall be constructed on the high side of superelevated curves immediately upon completion of the leveling course and base widening of the curve. The contractor shall also roughly shape the shoulders and provide for surface drainage when work is to be discontinued for an extended period.

**213.2.4** Shaping shoulders shall also include adjusting grades on existing entrances and approaches as necessary to meet shoulder grades. Such adjustments shall extend to the right of way line, if necessary to provide a satisfactory approach grade.

**213.2.5** Shaping shoulders shall start when enough of the final surfacing course has been placed and cured that the operation of shaping shoulders can be practicably continuous. In no case shall the work of shaping shoulders be delayed after one mile (1.5 km) of surfacing has

been completed and has cured sufficiently to support equipment for shaping shoulders without damage to the surface.

**213.3 Method of Measurement.** Measurement will be made to the nearest 0.01 mile (15 m) along the centerline of the pavement. Measurement will include shaping shoulders on both sides of the centerline regardless of roadbed width.

**213.3.1** Shaping Shoulders, Class 1 or Class 2, will apply only to those sections that have been specifically designated as such on the plans and the class will not be subject to change during construction.

**213.3.2** Final measurement will not be made except where appreciable errors are found in the contract quantity. The correction will be added to or deducted from the contract quantity.

**213.4 Basis of Payment.** No direct payment will be made for any additional material required for completion of the shoulders.

**213.4.1** The contractor will not be required to excavate any classified rock excavation under this item.

**213.4.2** The accepted quantity of shaping shoulders will be paid for at the unit price for each of the pay items included in the contract.

## SECTION 214

### WATER

**214.1 Description.** If any item of work included in the contract contemplates the payment for water as a separate item, water shall be applied as specified. The engineer reserves the right to omit all or any part of the quantity of water estimated for the particular work. The source and quality of water shall meet the approval of the engineer.

**214.2 Method of Measurement.** The quantity of water to be paid for will be determined by measurement in tanks or tank-trucks of pre-determined capacity or by meters of a type satisfactory to the engineer, which shall be furnished and installed by and at the contractor's expense. If meters are used, separate meters shall be installed at all outlets where water is discharged and used in that construction for which water is to be paid for as a contract item. Measurement will be made to the nearest 100 gallons (500 L).

**214.3 Basis of Payment.** The accepted quantity of water will be paid for at the contract unit price.

## SECTION 215

### SHAPING SLOPES

**215.1 Description.** This work shall consist of grading and shaping existing slopes in conformity with the lines, grades and typical sections shown on the plans or established by the engineer.

**215.1.1** Shaping Slopes, Class I, is defined as shaping slopes where, in general, the material required to bring the roadway to the designated cross section can be obtained or disposed of within the right of way limits as directed by the engineer.

**215.1.2** Shaping Slopes, Class II, is defined as shaping slopes where it may be necessary to go outside the limits of the right of way for additional material to construct the slopes to the designated cross section or where it may be necessary to dispose of waste material outside the limits of the right of way. The contractor shall provide the engineer with an acceptable written agreement with any property owner from whose property additional material is to be obtained or on which excess excavation is to be disposed.

**215.2 Construction Requirements.** Slope areas to be shaped by the addition of material shall be scarified to allow bonding with the added material. The density shall be that obtained from a reasonable compactive effort consisting of not less than three passes with a roller approved by the engineer.

**215.3 Method of Measurement.** Measurement will be made to the nearest 0.01 mile (15 m) separately for each length of slope measured along the centerline of the traveled way.

**215.3.1** Shaping Slopes, Class I or Class II, will apply only to those sections that have been specifically designated as such on the plans and the class will not be subject to change during construction.

**215.3.2** Final measurement will not be made except where appreciable errors are found in the contract quantity. The correction will be added to or deducted from the contract quantity.

**215.4 Basis of Payment.** No direct payment will be made for any additional material required for shaping slopes.

**215.4.1** The contractor will not be required to excavate any classified rock excavation under this item.

**215.4.2** The accepted quantity of shaping slopes will be paid for at the unit price for each of the pay items in the contract.



# **DIVISION 300**

## ***BASES AND AGGREGATE SURFACES***



## SECTION 301

### PLANT MIX BITUMINOUS BASE COURSE

**301.1 Description.** This work shall consist of aggregate, filler if needed, and asphalt binder mixed in a stationary bituminous mixing plant in such proportions that the resulting mixture meets the grading requirements of the job-mix formula. The mixture shall be placed, spread and compacted in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer.

**301.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Coarse Aggregate	1002.1.1 to 1002.1.2 incl.
Fine Aggregate	1002.2
Mineral Filler	1002.3
Hydrated Lime	1002.4
Asphalt Binder, Performance Graded (PG)	1015

The grade of asphalt binder will be specified in the contract.

**301.2.1** The gradation of coarse aggregate shall be such that the total aggregate meets the gradation requirements specified in [Sec 301.3](#) prior to being fed into the cold aggregate feeders.

**301.2.2** When screenings are used, they shall be considered coarse aggregate consisting of tough, durable particles of approved quality, and shall be free from dirt or other objectionable material. The fraction passing a No. 40 (425 µm) sieve shall be non-plastic.

**301.3 Composition of Mixtures.** The bituminous base shall be composed of a mixture of crushed limestone or dolomite, except as hereinafter permitted, filler if needed, and asphalt binder. The total aggregate prior to mixing with asphalt binder shall meet the following gradation requirements:

Sieve Size	Percent Passing by Weight (Mass)
1 inch (25.0 mm)	100
1/2 inch (12.5 mm)	60-90
No. 4 (4.75 mm)	35-65
No. 8 (2.36 mm)	25-50
No. 30 (600 µm)	10-35
No. 200 (75 µm)	5-12

At the option of the contractor, fine aggregate may be incorporated into the mixture. The total quantity of such fine aggregate shall not exceed 30 percent by weight (mass) of the combined aggregate and shall be added at the plant by means of a separate cold aggregate feeder.

**301.3.1** The composition of the mixture shall be as directed by the engineer and shall conform to the following limits by weight (mass):

Item	Percent
Total Mineral Aggregate	94-97
Asphalt Binder	3-6

**301.3.2** At least 30 days prior to preparing any of the mixture on the project, the contractor shall obtain, in the presence of the engineer, representative samples of asphalt binder and mineral aggregates for tests. The samples of the material shall be of the size specified by the engineer and shall be submitted to the Central Laboratory for testing. The contractor shall also submit for the engineer's approval, a job-mix formula for the mixture to be supplied for the project. No mixture will be accepted for use until the job-mix formula for the project is approved by the engineer. The job-mix formula shall be within the gradation range specified for bituminous base and shall include the type and sources of all material, the gradations of the aggregates and the relative quantity of each ingredient, if more than one, and shall state a definite percentage for each fraction of aggregate. No job-mix formula will be approved which does not permit within the limits specified in [Sec 301.3](#) and [301.3.1](#) the full tolerances specified in [Sec 301.3.4](#) for asphalt binder and not less than 1/2 the tolerances specified in [Sec 301.3.4](#) for material passing the No. 8 (2.36 mm) sieve and the material passing the No. 200 (75 µm) sieve. The job-mix formula approved for the mixture shall be in effect until modified in writing by the engineer. When unsatisfactory results or other conditions make it necessary, or should a source of material be changed, a new job-mix formula may be required.

**301.3.3** The engineer will make such changes in the proportions of asphalt binder and aggregates as considered necessary. The proposed mixture will be compacted and tested in the laboratory in accordance with AASHTO T 167 or AASHTO T 245, at the option of the engineer and modified as follows. The test method used shall be modified by aging the mixture for two hours, at the specified compaction temperature range of the asphalt binder, just prior to compaction of the specimens. The mixture of mineral aggregate and asphalt binder shall result in a bituminous mixture which will be durable and retain satisfactory cohesion and stability in the presence of moisture.

**301.3.3.1** Moisture susceptibility may be tested in accordance with AASHTO T 283 or AASHTO T 165, at the option of the engineer. A minimum retained strength of 70 percent shall be obtained when tested for moisture susceptibility. If requested by the contractor, hydrated lime may be added to increase retained strength to a passing level.

**301.3.4 Gradation Control.** In producing mixtures for the project, the plant shall be so operated that no intentional deviations from the job-mix formula are made. Mixtures as produced shall be subject to the following tolerances and controls:

- (a) The total aggregate gradation shall be within the master range specified in [Sec 301.3](#).
- (b) The maximum variations from the approved job-mix formula shall be within the following tolerances:

Passing No. 8 (2.36 mm) sieve	±5.0 percentage points
Passing No. 200 (75 µm) sieve	±2.0 percentage points

- (c) The quantity of asphalt binder introduced into the mixer shall be that quantity specified in the job-mix formula. No change may be made in the quantity of asphalt binder specified in the job-mix formula without written approval of the engineer. The quantity of asphalt binder determined by calculation or tests on the final mixture shall not vary more than ±0.5 percentage point from the job-mix formula.

**301.3.5** The gradations of the total aggregate will be determined from samples taken from the hot bins on batch-type plants or continuous mixing plants or from the composite cold feed belt on drum mix plants. Batch-type or continuous mixing plants shall have a screening unit which separates the usable heated aggregate into at least two sizes. One of the aggregate bin sizes produced by the screening unit shall contain not more than 10 percent by weight (mass) retained on the No. 4 (4.75 mm) sieve.

**301.3.6** At the option of the contractor and at no revision in unit price of either the asphalt binder or the mineral aggregate, the contractor may use an approved Type IB or Type IC asphaltic concrete mixture, produced in accordance with the requirements of [Sec 403](#), in lieu of the plant mix bituminous base course mixture. When this substitution is made, the layer thickness, roller and density requirements of [Sec 301](#) will apply.

**301.3.7 Commercial Mixture.** If specified in the contract that an approved commercial mixture may be used, the contractor shall, at least seven days prior to the desired time of use, furnish a statement setting out the source and characteristics of the mixture proposed to be furnished. The statement shall include: (1) the types and sources of aggregates, percentage range of each and range of combined gradation; (2) the percent and grade of asphalt binder; and (3) the mixing time and range of mixture temperature. The plant shall be designed and operated to produce a uniform, thoroughly mixed material free from segregation. It will not be necessary for the plant to meet the requirements of [Sec 301.6](#). A field laboratory will not be required. If the proposed mixture and plant are approved by the engineer, the component material and the mixture delivered will be accepted or rejected by visual inspection. The supplier shall furnish with the first truck load of each day's production, a certification in triplicate that the material and mixture delivered are in conformance with the approved mixture. Upon completion of the work, a plant certification in triplicate shall be furnished by the supplier for the total quantity delivered. The mixture shall be transported and placed in accordance with the requirements specified in [Sec 301.8](#) through [301.12](#) and shall be compacted as specified in [Sec 301.11](#).

**301.3.7.1** Without specific contract designation, an approved commercial mixture meeting the requirements of [Sec 301.3.7](#) may be used in lieu of plant mix bituminous base course mixtures for work that is considered temporary construction and is to be maintained at the contractor's expense. Temporary construction is work that is to be removed prior to completion of the contract.

**301.4 Field Laboratory.** The contractor shall provide a Type 3 Field Laboratory meeting the requirements of [Sec 601](#). No direct payment will be made for providing the laboratory.

### Construction Requirements

**301.5 Weather Limitations.** Bituminous mixtures shall not be placed (1) when either the air temperature or the temperature of the surface on which the mixture is to be placed is below 40 F (5 C), (2) on any wet or frozen surface, or (3) when weather conditions prevent the proper handling or finishing of the mixture. Temperatures are to be obtained in accordance with MoDOT Test Method T20.

**301.6 Bituminous Mixing Plants.** Bituminous mixing plants and preparation of material and mixtures shall conform to the requirements of [Sec 404](#).

**301.7 Subgrade Preparation.** The subgrade upon which the bituminous mixture is to be placed shall be prepared in accordance with [Sec 209](#) and tacked or primed, as specified in the contract, in accordance with [Secs 407](#) and [408](#), as applicable.

**301.7.1** For widening work, the bottom of the trench shall be compacted until it is firm by use of a trench roller having a weight (mass) of not less than 300 pounds per inch (5.5 kg/mm) of width of rear roller, or by mechanical tampers or other methods approved by the engineer. Suitable excavated material may be used in shouldering operations. All surplus excavated material shall be disposed of by the contractor in areas to be secured by the contractor beyond the right of way limits. If surplus excavated material is disposed of outside the right of way, an acceptable written agreement with the property owner on whose property the material is placed shall be submitted by the contractor.

**301.7.1.1** On the outside of curves, the design depth of trench at the beginning of the superelevation transition shall be varied gradually to the minimum depth at the end of the superelevation transition. Slight transitioning of the width of the base widening will be necessary to permit the indicated angle of repose or shear angle outside of the ultimate edge of surface. The bottom of the trench shall in no case be less than 3 inches (75 mm) below the surface of the existing pavement.

**301.8 Hauling Equipment.** Trucks used for hauling bituminous mixtures shall comply with the requirements of [Sec 404](#).

**301.9 Spreading.** The base course, primed surface or preceding course or layer shall be cleaned of all dirt, packed soil or any other foreign matter prior to spreading the bituminous mixture. When delivered to the roadbed, the mixture shall be at a temperature which will permit proper placement and compaction. The mixture shall be spread with an approved spreading and finishing machine in the number of layers and in the quantity required to obtain the compacted thickness and cross section shown on the plans. The compacted thickness of a single layer shall not exceed 4 inches (100 mm) except as follows: (1) the uppermost layer directly under the surface course for traveled ways and auxiliary lanes shall be placed in a single layer not to exceed the width and thickness shown on the plans and not to exceed 3 inches (75 mm), or (2) in widening construction the material may be placed in two layers, provided the thickest layer is placed first and no individual layer has a compacted thickness greater than 7 inches (175 mm). On base widening work, a succeeding layer of bituminous mixture may be placed the same day as the previous layer, if it can be shown that the desired results are being obtained on small areas, and on areas which are inaccessible to mechanical spreading and finishing equipment, the mixture may be spread and finished by hand methods if permitted by the engineer.

**301.9.1** The mixture shall be spread without tearing the surface and struck off so that the surface is smooth and true to cross section, free from all irregularities, and of uniform density throughout. Care shall be used in handling the mixture to avoid segregation. Areas of segregated mixture shall be removed and replaced with suitable mixture. The outside edges of the base shall be constructed to an angle of approximately 45 degrees with the surface of the roadbed. The outside edge alignment shall be uniform and any irregularities shall be corrected by adding or removing mixture before compacting.

**301.9.2 Leveling Course.** If required by the contract, a leveling course consisting of a layer of variable thickness shall be spread to the desired grade and cross section to eliminate irregularities in the existing surface. Spot-leveling operations over small areas, with feather-edging at high points and ends of spot areas, may be required prior to placing the leveling course. Rigid control of the placement thickness of the leveling course will be required. The use of an approved finishing machine will be required on the spot-leveling and the leveling course, except that the spreading of the spot-leveling with a blade grader will be permitted if results indicate the mixture is practically free from segregation.

**301.9.3 Base Widening.** On projects requiring construction of base widening, the contractor will be permitted to construct the base widening either before or after placement of leveling courses; however, the widening shall be constructed so that placement of additional thickness of widening due to the variable thickness of the leveling course will not be required.

**301.9.3.1** At least one lane of the existing pavement and the adjacent shoulder shall be kept open to traffic at all times during construction, except for short intervals when the movement of the contractor's equipment will seriously hinder the flow of traffic. Intervals during which the contractor will be allowed to halt traffic shall be as designated by the engineer. The contractor shall not open more trench ahead of the first layer of the base widening than is necessary for placing that layer in 1/2 day's operations. The first layer of the base widening shall not be placed for a greater distance ahead of the second layer than is necessary for placing the second layer in 1/2 day's operations. The second layer shall not be placed for a greater distance ahead of the final layer than is necessary for placing the final layer in one day's operation. Any changes in these lengths shall be made only with the written permission of the engineer.

**301.10 Joints.** Longitudinal and transverse joints shall be carefully made and well bonded. The minimum density of all traveled way pavement within 6 inches (150 mm) of a longitudinal joint, including the pavement on the traveled way side of the shoulder joint, shall not be less than 2.0 percent below the specified density. Once an established procedure has been demonstrated to provide the required density for longitudinal joints, at the engineer's discretion, the procedure may be used in lieu of density tests provided no changes in the material, typical location or temperatures are made. Pay adjustments due to longitudinal joint density shall apply to the full width of the traveled way pavement and shall be in addition to any other pay adjustments. Transverse joints shall be formed by cutting back on the previous run so as to expose the full depth of the layer. When a transverse vertical edge is to be left and opened to traffic, a temporary depth transition shall be built as approved by the engineer. The longitudinal joints in one layer shall offset those in the layer immediately below by approximately 6 inches (150 mm).

**301.11 Compaction.** Rolling shall begin as soon after spreading the mixture as it will bear the weight (mass) of the roller without undue displacement. All rollers shall be in satisfactory condition capable of reversing without backlash, and steel wheel rollers shall be equipped with scrapers. Rollers shall have a system for moistening each roll or wheel. A trench roller shall be used on depressed areas inaccessible to regular width equipment. The compacted mixture shall have a density of not less than 95 percent of that obtained by the laboratory compaction of a specimen made in the proportions of the approved mixture. Density will be determined by the direct transmission nuclear method in accordance with MoDOT Test Method T41 or by a specific gravity method.

**301.11.1** In lieu of roller and density requirements, mixtures used for shoulders and temporary by-passes to be maintained at the expense of the contractor and areas where a commercial mixture is used shall be thoroughly compacted by at least three complete coverages over the entire area with either a pneumatic tire roller weighing (having a mass of) not less than 10 tons (9 Mg), a tandem-type steel wheel roller weighing (having a mass of) not less than 10 tons (9 Mg) or an approved vibratory roller. Rolling shall be performed at proper time intervals on each layer and shall be continued until there is no visible evidence of further consolidation.

**301.12 Surface Tolerance.** The finished layers shall be substantially free from waves or irregularities and shall be true to the established crown and grade. At transverse construction joints the surface of all layers shall not vary from a 10-foot (3 m) straightedge, applied parallel to the center line, by more than 1/4 inch (6 mm), except that the entire surface of the final

layer of plant mix bituminous base mixture shall not vary from the 10-foot (3 m) straightedge by more than 1/8 inch (3 mm) if this layer is used as the final riding surface course. Areas exceeding this tolerance shall be re-rolled, replaced or otherwise corrected in a manner satisfactory to the engineer.

**301.12.1** The surface of the mixture after compacting shall be smooth and true to the established crown and grade. Any mixture showing an excess of bituminous material or that becomes loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced with satisfactory mixture, which shall be immediately compacted to conform with the surrounding area.

**301.13** During construction, the engineer will make as many tests as are necessary to ensure that the course is being constructed of proper thickness, composition and density. The contractor shall cut samples of the compacted mixture from any layer at locations designated by the engineer and shall deliver them to the field laboratory in good condition. Samples may be obtained by either sawing with a power saw or by drilling 4-inch (100 mm) diameter cores. Each sawed sample shall consist of a single piece of the pavement of the size designated by the engineer but not larger than 12 inches (300 mm) square. Each cored sample shall consist of four cores. If the thickness of the layer is greater than 4 inches (100 mm), two cores will be required in lieu of four. All samples shall be taken the full depth of the layer to be tested and shall consist of an undisturbed portion of the compacted mixture. The surface from which samples have been taken shall be restored by the contractor not later than the next day of plant operation.

**301.14 Method of Measurement.** The weight (mass) of the mixture will be determined from the batch weights (masses) if a batch-type plant is used, and will be determined by weighing (by determining the mass of) each truck load on scales conforming to the requirements of [Sec 310.4.3](#) if other types of plants are used.

**301.14.1** Measurement of asphalt binder, to the nearest 0.1 ton (0.1 Mg) for the total tonnage (mass) used in the accepted work, will be determined by the use of the formula of the approved mixture applied to the weight (mass) of accepted mixture of mineral aggregate and asphalt binder.

**301.14.2** Measurement of the weight (mass) of mineral aggregate, to the nearest ton (megagram), will be determined by subtracting the weight (mass) of the asphalt binder from the weight (mass) of the mixed mineral aggregate and asphalt binder.

**301.15 Basis of Payment.** The accepted quantities of plant mix bituminous base course will be paid for at the unit price for each of the pay items included in the contract. Payment for obtaining and delivering samples of compacted mixture from the base and replacement of the surface will be made at \$75.00 per sample.

**301.15.1** No direct payment will be made for excavating the trench for base widening, or for hauling and disposing of excess excavation material.



## SECTION 302

### STABILIZED PERMEABLE BASE

**302.1 Description.** This work shall consist of furnishing and placing a stabilized permeable base material. The mixture shall be placed, spread and compacted in conformity with the lines, grades, thickness and typical cross sections shown on the plans or established by the engineer.

**302.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Aggregate for Drainage	<a href="#">1009</a>
Asphalt Binder (PG 64-16, PG 64-22, PG 70-22, PG 76-22)	<a href="#">1015</a>
Portland Cement	<a href="#">1019</a>
Water	<a href="#">1070</a>

**302.2.1 General.** Stabilized permeable base shall be either asphalt binder or portland cement stabilized at the option of the contractor. All stabilized permeable base shall use Grade 4 drainage aggregate meeting the requirements of [Sec 1009](#).

**302.2.2 Asphalt Stabilized Permeable Base.** Mixtures shall be composed of the base aggregate and 2.0-3.0 percent asphalt binder by weight (mass) of the total mixture. The composition of the mixture shall be as determined by the engineer in conformance with applicable portions of [Sec 301](#). All proportioning, mixing and transporting shall be in accordance with applicable sections of [Sec 301](#). PG 64-16, PG 64-22, PG 70-22 or PG 76-22 asphalt binder shall be used.

**302.2.3 Cement Stabilized Permeable Base.** Cement stabilized base mixtures shall be composed of the base aggregate with a cement factor of 2.0-3.0 sacks per cubic yard (112-167 kg/m<sup>3</sup>). All proportioning, mixing and transporting shall be in accordance with applicable provisions of [Sec 501](#). Unless otherwise specified, any approved type of cement may be used. Fly ash shall not be used.

#### 302.3 Construction Requirements.

##### 302.3.1 General.

**302.3.1.1** Care shall be taken to avoid contamination of the finished base material from soil or other fine material which could affect the drainage capability of the product. Any areas determined to be contaminated shall be cut out, completely removed without disturbing the subgrade and replaced at no additional cost.

**302.3.1.2** Construction traffic on permeable base material shall be limited to that required to place the overlying pavement material. Haul lengths on permeable base shall be kept as short as possible.

**302.3.1.3** Rutting or other displacement of the underlying base shall be avoided when placing the permeable base. If displacement occurs which could result in ponding or a non-uniform, non-draining thickness of permeable base, all permeable base operations shall cease until the grade is re-established and suitable equipment for placement is provided.

**302.3.2 Asphalt Stabilized Permeable Base.** Applicable portions of [Sec 301](#) shall apply, except as noted herein. The final mixture, when discharged from the pugmill or drum, shall be 250-300 F (120-150 C). The mixture shall still meet the maximum moisture content as specified in [Sec 404](#). A minimum of three passes of a 5 to 10 ton (4.5 to 9 Mg) steel wheel roller shall be made, compacting the material until no further displacement is noted. Vibratory rollers shall not be used. Compaction shall begin as soon after spreading the mixture as it will bear the weight (mass) of the roller without undue displacement and shall be completed before the temperature of the mixture drops below 100 F (38 C). The minimum compacted thickness of a single layer shall be 4 inches (100 mm). If more than 4 inches (100 mm) is necessary, the approximate compacted thickness of each lift shall not exceed 4 inches (100 mm).

**302.3.3 Cement Stabilized Permeable Base.** Applicable portions of [Sec 502](#) shall apply, except as noted herein. The water content of the mixture shall be adjusted to minimize segregation of the mixture. Normal concrete pavement consolidation equipment such as vibrators or vibrating pans will be considered as adequate, provided the mixture can be satisfactorily compacted. The mixture shall be cured for a minimum of 48 hours in accordance with [Sec 502.12](#), except that white pigmented membrane or straw shall not be used. At the contractor's option, a fine water mist may be applied several times each day for the 48 hour period as needed to maintain moisture. The water application shall not be heavy enough to wash away the cementitious material or mortar.

**302.4 Method of Measurement.** Measurement of permeable base complete in place will be made to the nearest square yard (meter). Final measurement of the completed permeable base will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity.

**302.5 Basis of Payment.** The accepted quantities of permeable base of the thickness specified will be paid for at the unit price for the pay items included in the contract for either "Stabilized Permeable Base". The price shall include all work and material, including stabilizing agent, necessary to provide the pay item in place.

## SECTION 303

### ROCK BASE

**303.1 Description.** This work shall consist of furnishing and placing select rock excavation material in the top two feet (600 mm) of the subgrade, in conformance with the lines, grades and typical cross sections shown on the plans or established by the engineer, for use as a base to provide pavement support and drainage.

**303.1.1** Except as noted herein, all applicable provisions in [Sec 203](#) for the handling and placement of roadway excavation material shall apply.

**303.2 Material.** The material source for rock base shall meet the approval of the engineer. Geologic conditions may vary from available subsurface information. Approval by the engineer of a source for the inherent stone does not constitute approval of the final rock base product. Additional mechanical processing beyond excavation such as, but not limited to, scalping, size reduction, washing, etc., of the material may be necessary to comply with this specification.

**303.2.1** Material for rock base shall be durable stone or broken concrete containing a combined total of not more than 10 percent of earth, sand, shale and non-durable rock. Material from geologic filled sink deposits or stone indicating evidence of solution activity shall not be used.

**303.2.2** The material shall be as large as can be conveniently handled within the limits of this specification. No particle dimension shall exceed 18 inches (450 mm). There shall be at least some material with particle dimensions exceeding 12 inches (300 mm). The material shall be uniformly graded from coarse to fine.

**303.2.3** Broken sound concrete pavement may be used provided the ratio of the longest dimension measurement to thickness does not exceed 2:1 and provided there is no excessive exterior steel mesh that would affect compaction. Concentrated forms of bituminous pavement (milled, crushed or chunked) shall not be used. Small, thin amounts adhering to broken concrete pavement will be allowed.

**303.2.4** Acceptance of quality and size of material may be made by visual inspection at the job site.

#### **303.3 Construction.**

**303.3.1** The material shall not be dumped in place, but shall be distributed by blading or dozing in a manner to ensure proper placement in final position in the subgrade.

**303.3.2** Rock base shall be 24 inches (600 mm) thick and may be placed in one lift. Rock base material may be placed thicker, in maximum 24-inch (600 mm) lifts, provided a uniform drainage plane under the rock base is provided, however no additional pay will be made for the thicker rock base material. Undergrading in rock cuts shall be performed to allow placement of the full specified lift thickness.

**303.3.3** The material shall be compacted in accordance with the requirements of [Sec 203.3.5](#).

**303.3.4** Regardless of whether the contract includes paving over the rock base, the final surface shall be of a uniform texture and grade suitable to the engineer for paving. The top approximately 2 inches (50 mm) of the rock base shall consist of either 2-inch (50 mm) maximum rock fragments or spalls or a 2-inch (50 mm) maximum size granular type material having a plasticity index not to exceed 10 and a gradation such that at least 50 percent of the material will be retained on the No. 4 (4.75 mm) sieve. There shall be no exposed rock exceeding the 2-inch (50 mm) size in the final surface that would interfere with final preparation of the base for paving.

**303.3.5** The rock base shall conform generally to existing lines, grades, slopes and to the minimum width as shown on the plans. A roughly compensating maximum deviation of 1/2 inch (13 mm), plus or minus, from the required elevation will be permitted on the surface of the finished rock base.

**303.3.6** Unless otherwise specified when the contract includes paving over existing rock base, the paving contractor shall adjust the rock base grade as needed to that required using approved backfill material as specified herein. No additional pay will be made for this adjustment unless specifically provided for.

**303.4 Method of Measurement.** Other than for errors or authorized changes in quantities, no final measurement will be made.

**303.5 Basis of Payment.**

**303.5.1** If shown on the plans that the material for rock base is to be obtained from the right of way or other source furnished by the Commission, the excavating, together with all breaking, processing, loading and hauling, regardless of distance, to the site of the rock base will be paid for and considered completely covered under such contract items as Class A Excavation, Class C Excavation, Unclassified Excavation, Excavation for Structures, or other applicable items. If payment is made under these conditions, separate payment for furnishing rock base will not be made.

**303.5.1.1** If the plans show material for rock base to be secured from such sources and this material is made unsuitable or unattainable by the contractor's operations, the contractor shall provide suitable material and dispose of any surplus material, at the contractor's expense.

**303.5.1.2** If the plans provide for obtaining material from the right of way or other source furnished by the Commission, but all or part of the required quantity of acceptable material is not actually available, payment will be made at the unit price of \$3.00 per square yard (\$3.60/m<sup>2</sup>) in place for such additional rock base material that the contractor is required to furnish and haul.

**303.5.2** If the plans do not provide for a source of material, the contractor shall provide the material. All costs of securing the source, quarrying, excavating, breaking, processing and hauling the material to the site will be paid for and completely covered by the contract unit price per square yard (square meter) for furnishing rock base.

**303.5.3** Payment for placing rock base will be made at the contract unit price per square yard (square meter) in place, based on the top surface area and 24 inches (600 mm) thick. No additional payment will be made for material needed to maintain the required edge slopes.

## SECTION 304

### AGGREGATE BASE COURSE

**304.1 Description.** This work shall consist of furnishing and placing one or more courses of aggregate on a prepared subgrade in accordance with these specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer. The type of aggregate to be used will be specified in the contract.

**304.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Aggregate for Base	1007

#### 304.3 Construction Requirements.

**304.3.1 Field Laboratory.** When authorized by the engineer, the contractor shall provide a Type 2 Field Laboratory meeting the requirements of [Sec 601](#). Payment for the laboratory will be made as provided in [Sec 601](#).

**304.3.2 Subgrade.** All work on that portion of the subgrade on which the base is to be constructed shall be completed in accordance with the requirements of [Sec 209.3.1](#) prior to the placing of any base material on that portion. Aggregate base shall not be placed on a frozen subgrade.

**304.3.3 Mixing.** Unless otherwise specified, base material, any additional material required and sufficient water to obtain the desired compaction shall be thoroughly mixed and delivered to the road as a combined product.

**304.3.4 Placing.** The maximum compacted thickness of any one layer shall not exceed 6 inches (150 mm). If the specified compacted depth of the base course exceeds 6 inches (150 mm), the base shall be constructed in two or more layers of approximately equal thickness. The compacted depth of a single layer of the base course may be increased to 8 inches (200 mm) for shoulders and lightly traveled areas.

**304.3.4.1** The contractor shall be responsible for placing the correct quantity of base material on the roadbed to construct a base conforming with the contract. Excess material shall be hauled ahead and reused, or loaded into trucks and measured or weighed (measured or the mass determined) over scales furnished by the contractor. Only material incorporated in the completed base will be included in the quantity allowed for payment.

**304.3.4.2** If the contractor elects to construct concrete pavement by slip-form methods in accordance with [Sec 502.16](#), the width of the aggregate base shown on the plans shall be increased to provide a 3-foot (1 m) width outside the edge of the pavement being placed.

**304.3.4.3** Types 1, 2, 4 and 5 aggregate base used for shoulders adjacent to rigid or flexible type pavement, including pavement resurfacing, shall be simultaneously deposited and spread on the subgrade with an approved spreading machine. Aggregates shall not be deposited on the pavement and bladed or dozed into place.

**304.3.5 Shaping and Compacting.** Immediately before spreading the mixture, the subgrade shall be sprinkled as directed by the engineer. The mixture shall be uniformly spread in successive layers of such depth that when compacted, the base will have the approximate thickness specified. Each layer shall be compacted to the specified density before another layer is placed, with the following exception. If difficulty is encountered in obtaining the specified density after reasonable compactive effort has been expended on the first lift placed over Type 4 aggregate base, the engineer may permit placing another layer. The testing for density will then be made on the combined lifts or layers.

**304.3.5.1** Segregated surface areas constructed of Types 1 or 2 aggregate base may be corrected by adding and compacting limestone screenings of such gradation and quantity as required to fill the surface voids, and firmly bind the loose material in place. Screenings used in correcting segregated surface areas will be measured and paid for as base material. Type 5 aggregate base is intended to provide some drainage and shall not be segregated. Trimmed Type 5 aggregate base may not be reused until it is verified as meeting the required specifications. Base material contaminated to such an extent that it no longer complies with the specifications shall be removed and replaced with satisfactory material at the expense of the contractor.

**304.3.5.2** Shaping and compacting shall be performed until a true, even and uniform surface of proper grade, cross section and density is obtained. Types 1 and 2 aggregate base used for shoulders shall be compacted to not less than 95 percent of standard maximum density. Types 1 and 2 aggregate base used on other than shoulders and Type 5 aggregate base under both roadway and shoulders shall be compacted to not less than standard maximum density. The Standard Compaction Test will be made in accordance with AASHTO T 99, Method C, replacing any material retained on the 3/4-inch (19.0 mm) sieve, as provided therein. Field density will be determined in accordance with AASHTO T 191 or T 205, using the total material or AASHTO T 238, Method B Direct Transmission, for wet density. The volume of the test hole may be reduced as necessary to accommodate available testing equipment. If nuclear density test methods are used, moisture content will be determined in accordance with AASHTO T 239, except that a moisture correction factor will be determined for each aggregate in accordance with MoDOT Test Method T35. In lieu of the density requirements for Types 1 and 2 aggregate base used for shoulders with thicknesses less than 4 inches (100 mm), the aggregate shall be compacted by not less than three complete coverages with a 5 ton (4.5 Mg) roller. Rolling shall be continued until there is no visible evidence of further consolidation. In lieu of the density requirement, the compacting of Type 4 aggregate base shall continue until the material is sufficiently compacted and stabilized to permit adequate densification of the upper portion of the shoulder or base. During shaping and compacting operations the moisture content of the base shall be maintained at the level necessary for compaction by wetting or drying as required. Final rolling shall be accomplished by a self-propelled smooth-wheeled roller weighing not less than 5 tons (having a mass of not less than 4.5 Mg).

**304.3.5.3** Shaping of the completed surface of the aggregate base for flexible type surfacing shall be continued until the deviation from the required elevation does not exceed a roughly compensating maximum of 1/2 inch (13 mm). The surface of aggregate base for rigid type surfacing shall be brought to proper crown and elevation in accordance with the requirements of [Sec 502.6](#).

**304.3.5.4** The surface of the aggregate base shall be well drained at all times. If at any time the compacted aggregate base or subgrade becomes unstable, the contractor, at the contractor's expense, shall restore the earth subgrade and the aggregate base to the required grade, cross section and density.

**304.3.5.5** If measurement of aggregate base course by area, complete in place, is specified, thickness of the aggregate base will be determined from measurements through the finished base at approximately 1000-foot (300 m) intervals. When the measurement indicates the thickness is deficient in excess of 1/2 (13 mm) inch from the plan thickness, additional measurements will be taken at 100-foot (30 m) intervals parallel to centerline ahead and back of the affected location until the extent of the deficiency has been determined. It will be assumed that each measurement is representative of the base thickness for a distance extending one-half the distance to the next measurement, measured along centerline, or in the case of a beginning or ending measurement, the distance will extend to the end of the base section. Any deficient areas shall be corrected by reworking and adding material within the limits of the deficiency.

**304.3.6 Maintenance.** When the aggregate base is to be constructed in more than one layer, the contractor shall maintain each layer by wetting or drying, blading and rolling in a manner satisfactory to the engineer, until it is covered by the next layer. This maintenance, including necessary water, shall be entirely at the contractor's expense. If a prime coat is specified in the contract, the contractor will be required to apply the prime coat on any completed portion of the aggregate base as soon as practicable, or as otherwise specified. However, the contractor will not be permitted to apply prime if the moisture in the top 2 inches (50 mm) of the aggregate base exceeds the higher of either (1) the average of the optimum moisture as determined by the standard compaction test and the absorption of the plus No. 4 (4.75 mm) fraction, or (2) two-thirds of the optimum moisture as determined by the standard compaction test. The contractor shall maintain the required density and surface condition of any portion of the completed aggregate base until either the prime or a succeeding course or pavement is placed.

#### **304.4 Method of Measurement.**

**304.4.1 Measurement of Aggregate by Volume.** Measurement will be made in the vehicle at the point of unloading. The contractor shall strike off and level each load for inspection and checking. Measurement will be made to the nearest 1/4 cubic yard (0.1 m<sup>3</sup>) for each load and to the nearest cubic yard (cubic meter) for the total quantity of material accepted. Additional material required by [Sec 304.3.4.2](#) will be deducted from the total quantity of material accepted.

**304.4.2 Measurement of Aggregate by Weight (Mass).** Measurement will be made by weighing each truck load (determining the mass of each truck load) on scales conforming to the requirements of [Sec 310.4.3](#). Deductions for excess moisture will be made as follows:

(a) Types 1, 2, 3 and 5 Aggregate for Base. Deduction will be made for moisture in the total material in excess of one percentage point over optimum moisture as determined by the standard compaction test.

(b) Type 4 Aggregate for Base. Deduction will be made for any moisture in excess of 2 percent of the dry weight (mass) of the material.

(c) After deduction for excess moisture, measurement will be made to the nearest ton (megagram) for the total tonnage (mass) of material accepted. Additional material required by [Sec 304.3.4.2](#) will be deducted from the total quantity accepted.

**304.4.3 Measurement of Aggregate Base Course by Area.** Measurement of aggregate base course complete in place will be made to the nearest square yard (square meter), except that the area of additional material required by [Sec 304.3.4.2](#) will not be included. Separate

measurement will be made for each type and each thickness of base course. Final measurement of the completed aggregate base course will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity. Where the aggregate base course extends to the inslope of the shoulder, the pay limit of the aggregate base course will be measured from the mid-point of the sloped portion.

**304.5 Basis of Payment.** The accepted quantities of aggregate base course of the thickness and type specified will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for water used in performing this work.



## SECTION 306

### MODIFIED SUBGRADE

**306.1 Description.** This work shall consist of modifying a wet subgrade to improve stability prior to paving operations. This work may be performed at the contractor's option and with concurrence of the engineer, within the limits of this specification.

**306.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows.

**306.2.1** The modifying material is specifically limited to hydrated lime, with no substitutes. Hydrated lime shall meet the chemical and physical characteristics of AASHTO M 216. The supplier shall furnish certification to the same for each load. Hydrated lime shall be kept free from moisture prior to use. Lime stored on the project shall be placed in weatherproof bins or buildings with adequate protection from ground dampness.

#### **306.3 Construction Requirements.**

##### **306.3.1 Application.**

**306.3.1.1** The contractor may determine the locations, amount of modifying material and depth of application, within the limits of this specification and subject to the concurrence of the engineer. No lift shall exceed 6 compacted inches (150 compacted millimeters), however there is no limit to the number of lifts that may be modified.

**306.3.1.2** Mixing equipment may include disk harrows or rotary mixers, or other equipment which provides uniform mixing and is approved by the engineer.

**306.3.1.3** Where subgrade modification is performed, it shall be done to all areas uniformly and laterally between outside shoulder points plus 18 inches (450 mm) on each side. Furthermore, when the modified areas are stopped and started, there shall be a longitudinal transition zone, at the rate of 30 feet per 6 inches (9 m per 150 mm) of modified depth. The transition may be made by reducing modifying material or mixing depth.

**306.3.1.4** The modifying material shall be spread in uniform and regular patterns. No material shall be applied if it is being blown from the work area.

**306.3.1.5** Hydrated lime shall be applied at a dry rate of not less than 15 pounds per square yard (8 kg/m<sup>2</sup>) for the depth modified, nor more than 26 pounds per square yard per 6 inches (13 kg/m<sup>2</sup> per 150 mm) of depth modified.

**306.3.2 Compaction.** The subgrade shall be uniformly mixed with the modifying material. Mixing and compaction shall continue until the subgrade is shown to have suitable compaction as demonstrated by the roller equipment. Density and moisture testing will ordinarily be waived for subgrade modified under this specification, except that should compaction not be demonstrated to the engineer's satisfaction, the engineer reserves the right to run such tests as necessary to ensure density.

##### **306.4 Method of Measurement.**

**306.4.1** Measurement will be made to the nearest square yard (square meter) as measured along the centerline of the roadway including transition areas and for the affected width. Subgrade meeting all other requirements, suitable for the placing of base material and having modifying material incorporated as specified herein, will be paid for at the designated price per square yard (square meter) except as noted herein.

**306.4.2** Reimbursement for transition areas will be made at the rate of 1/2 the payment for modified subgrade.

**306.4.3** Reimbursement will be limited to modified areas, the width of the pavement and shoulders, plus a maximum of 18 inches (450 mm) on each side.

**306.4.4** Only one payment for modified subgrade will be made for any area, regardless of the depth of stabilized material, number of applications or other circumstances.

**306.5 Basis of Payment.** Payment for modified subgrade will be made at the rate of \$1.00 per square yard (\$1.20/m<sup>2</sup>) of modified subgrade, regardless of depth.

## SECTION 308

### PORTLAND CEMENT-TREATED BASES

#### SECTION 308.10 PORTLAND CEMENT-TREATED BASE, CENTRAL PLANT METHOD

**308.11 Description.** This work shall consist of constructing one or more courses of a mixture of water, portland cement and aggregate or soil on a prepared subgrade in accordance with these specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer.

**308.12 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Liquid Asphalt (RC-70, MC-30 or MC-70)	1015
Portland Cement, Type I	1019
Water	1070

Soil or Aggregate - The gradation and other requirements will be specified in the contract.

The grade of liquid asphalt will be specified in the contract.

**308.12.1** Representative samples of the soil or aggregate shall be obtained by the contractor in the presence of the engineer in time to permit delivery to the Central Laboratory for testing at least seven weeks prior to the preparation of any of the mixture on the project. The cement content to be used will be designated by the engineer.

#### **308.13 Equipment.**

**308.13.1 Plant.** The soil or aggregate, cement and water shall be thoroughly and uniformly mixed in the specified proportions by an approved central plant of the batch or continuous flow type. The plant shall be equipped with weighing or metering devices capable of controlling the cement content within 0.5 percentage point of that specified. The plant shall be calibrated by the contractor in the presence of and subject to the approval of the engineer. A portable beam scale of 500-pound (200 kg) capacity, together with ten 50-pound (20 kg) standard test weights and a 55-gallon (200 liter) container, shall be made available at the plant by the contractor at all times for checking the accuracy of the equipment. The mixing equipment shall be capable of producing at least 100 tons (90 Mg) per hour for contracts totaling 30,000 square yards (25,000 m<sup>2</sup>) or less, and at least 200 tons (180 Mg) per hour for contracts totaling more than 30,000 square yards (25,000 m<sup>2</sup>).

**308.13.2 Spreaders.** Spreaders shall be equipped with adjustable screeds to maintain the required width, thickness and cross section, and shall be sufficient in number and capacity to handle production of the plant. Spreaders propelled by trucks will not be permitted.

**308.13.3 Distributors.** Pressurized distributors in satisfactory condition shall be capable of maintaining the specified moisture content of the mixture on the roadway during construction.

**308.13.4 Rollers.** Rollers shall be capable of producing the required density and finish. Tamping rollers shall have wedge or cone shaped feet, and may be propelled by a separate unit. All other types of rollers shall be self-propelled.

**308.13.5 Miscellaneous Equipment.** A spike-tooth harrow or similar device shall be used as necessary to minimize compaction planes. A broom drag shall be provided for use in final surface finishing. Miscellaneous equipment shall be propelled by pneumatic-tire vehicles.

**308.14 Field Laboratory.** When authorized by the engineer, the contractor shall provide a Type 2 Field Laboratory meeting the requirements of [Sec 601](#). Payment for the laboratory will be made as provided in [Sec 601](#).

**308.15 Construction Requirements.**

**308.15.1 Subgrade.** All portions of the roadbed, upon which the cement-treated base is to be constructed, shall be shaped to within a roughly compensating maximum deviation of 1/2 inch (13 mm) of the grade and cross section shown on the plans. Any soft or yielding subgrade shall be removed, and backfilled with approved material. If such correction is necessary as a result of the contractor's negligence or of his operations, repairs shall be made at the contractor's expense.

**308.15.2 Borrow.** The contractor shall excavate the borrow area in such manner that the material obtained from the deposit complies with the requirements of the contract. The borrow area may include layers that will require mixing to produce acceptable material. It may also contain deposits that are to be avoided as they may not be acceptable for use in the cement-treated base.

**308.15.3 Mixing.** Water shall be added during the mixing operation as required to provide the quantity of moisture specified for compaction. However, water shall not be added to the mixture before the soil and cement have been mixed sufficiently to prevent the formation of cement balls. The moisture content specified for the total material of the mixture shall be determined by tests on samples obtained during construction. Until such tests can be made, the optimum moisture content determined by the Central Laboratory shall be used. When expelled from the mixer, at least 80 percent of the cement-treated mixture, exclusive of gravel, stone and lumps of bituminous material shall pass the No. 4 (4.75 mm) sieve, and shall generally contain no clods of soil larger than one inch (25 mm). However, if clods are at or above their optimum moisture content, their maximum permissible size shall be 1 1/2 inches (38 mm), and the minimum passing the No. 4 (4.75 mm) sieve, exclusive of gravel, stone or lumps of bituminous material, shall be 70 percent.

**308.15.4 Hauling and Spreading.** The cement-treated mixture shall be hauled in tight vehicles free from foreign matter. The subgrade shall be sprinkled immediately before placing the mixture. The mixture shall be simultaneously deposited and spread on the subgrade. Not more than 60 minutes shall elapse between the mixing and spreading. The mixture shall not be placed on frozen subgrade nor shall it be placed unless the ambient temperature is at least 40 F (5 C) and rising.

**308.15.4.1** Edges of the cement-treated mixture against which adjacent lanes will be spread shall remain uncompacted for a width not to exceed 18 inches (450 mm) until the adjacent mixture is spread, but shall not remain exposed for more than 45 minutes. If adjacent lanes cannot be placed within that time, the edge of the previously placed mixture shall be cut back to a point where it meets the proper line and grade, and trimmed to a vertical face parallel to the centerline of the roadway prior to resuming spreading operations.

**308.15.4.2** To form a transverse construction joint, the end of a complete portion shall be cut back to a point where it meets proper grade and crown, and shall be trimmed to a vertical face at right angles to the centerline for the full depth and width of the cement-treated base.

**308.15.5 Compacting.** Compacting shall start immediately after spreading, and shall continue until not less than 95 percent of standard maximum density has been attained.

**308.15.5.1** During compacting operations, the percentage of moisture in the total material of the mixture shall not vary from the optimum moisture content as determined by the standard compaction test by more than 2.0 percentage points. If the moisture falls more than 2.0 percentage points below optimum, the contractor shall add sufficient water with pressure distributors to maintain the moisture within the tolerance. If the moisture content at any time during construction exceeds the upper limit, the mixture may be dried by aeration until the moisture content has been satisfactorily reduced, and then compacted and finished. If this cannot be accomplished within the time limits specified in [Sec 308.15.6](#), the entire affected area shall be removed and replaced, or shall be corrected by mixing in an additional 50 percent of the original cement content and completing the operations, at the contractor's expense for both the processing and additional cement required.

**308.15.5.2** The Standard Compaction Test will be performed at the start of the compacting operation, in accordance with AASHTO T 99, Method C, replacing any material retained on the 3/4-inch (19.0 mm) sieve, as provided therein. The field density of the portland cement-treated material after compaction will be determined in accordance with AASHTO T 191 or T 205, using the total material or T 238, Method B Direct Transmission, for wet density. The volume of the test hole may be reduced as necessary to accommodate available testing equipment. If nuclear density methods are used, moisture content will be determined in accordance with AASHTO T 239, except that a moisture correction factor will be determined in accordance with MoDOT Test Method T35. The calculated density obtained in a field density test will be compared with the maximum density as established by the Standard Compaction Test to determine the percent compaction attained.

**308.15.5.3** To avoid the necessity for frequent field density tests, the contractor shall, near the beginning of the work, build a test section not less than 500 feet (150 m) long, for the full width of the proposed treatment, for the purpose of establishing the procedure required to attain the density specified in [Sec 308.15.5](#). For the remainder of the project, the portland cement-treated base may be assumed to meet the specified density requirements if the compacting procedure established by the test section has been used, and the moisture content of the total material during compacting operations has been maintained within 2.0 percentage points of optimum, as determined by the Standard Compaction Test, and there is no visible evidence of further consolidation. A new test section shall be built to establish a revised compacting procedure when there is an appreciable change in gradation or type of material, a change in source of material, a revision in the cement content, when density tests show inadequate compaction, or when in the judgment of the engineer a revised procedure is required.

**308.15.6 Shaping and Finishing.** Should the surface of the cement-treated base require shaping after the mixture has been compacted, harrowing may be necessary to minimize formation of compaction planes. The surface of the cement-treated base shall be kept moist during shaping and finishing operations. Surface compacting and finishing may be varied as necessary to produce, within five hours after the mixture is placed on the subgrade, a smooth, tightly knit surface. If the surface of the hardened cement-treated base crumbles or loosens under construction and public traffic, the loose material shall, at the contractor's expense, be removed and replaced with an equal thickness of approved bituminous mixture prior to placement of subsequent bituminous courses.

**308.15.7 Protective Cover.** The contractor shall apply a protective cover of bituminous material in accordance with [Sec 408](#), Prime Coat, not later than the next day after finishing any portion. The minimum air and surface temperature restrictions of [Sec 408](#) will not apply for this operation. The finished surface of the cement-treated base shall be kept continuously moist until the protective cover is applied. Sand blotter shall be applied when directed by the engineer as necessary to maintain local traffic. This protective cover may serve as a prime; however, it may be necessary to apply additional prime before constructing a surface course. At any time within seven days after placement, when the air temperature is expected to be 32 F (0 C) or below, the cement-treated base shall be protected against freezing with either a 3-inch (75 mm) thickness of loose soil or a 6-inch (150 mm) thickness of loose straw. Only pneumatic tire equipment required for applying the bituminous protective cover, sand blotter, and material used to protect against freezing will be permitted on the cement-treated base for seven days following completion, except where necessary to maintain local traffic. The contractor shall, at the contractor's expense, maintain completed portions in a satisfactory condition until acceptance of the work.

#### **308.16 Method of Measurement.**

**308.16.1** Measurement of cement will be made to the nearest barrel (100 kg). Measurement of bulk cement will be made by weighing (determining the mass of) each truck load on scales conforming to the requirements of [Sec 310.4.3](#). Hopper scales calibrated in a similar manner may be used in lieu of the vehicle scales. If bagged cement is used, the net weight (mass) as packaged by the manufacturer will be used for measurement.

**308.16.2** Measurement of the weight (mass) of soil or aggregate, to the nearest ton (megagram), will be determined by subtracting the weight (mass) of the cement from the weight (mass) of the mixture. The weight (mass) of the mixture will be determined from batch weights (masses) if a batch-type plant is used, and will be determined by weighing (determining the mass of) each truck load on scales conforming to the requirements of [Sec 310.4.3](#) if a continuous-type plant is used. No deduction will be made for the weight (mass) of water in the mixture.

**308.17 Basis of Payment.** The accepted quantities of portland cement-treated base will be paid for at the unit price for each of the pay items included in the contract. Payment for bituminous material and sand blotter for protective cover will be made in accordance with [Sec 408](#).

**308.17.1** No direct payment will be made for water used in performing this work.

#### **SECTION 308.20 PORTLAND CEMENT-TREATED BASE, ROAD MIX METHOD**

**308.21 Description.** This work shall consist of constructing one or more courses of a mixture of water, portland cement and soil or other designated material on a prepared subgrade in accordance with these specifications, and in conformity with the lines, grades, thicknesses and typical sections shown on the plans or established by the engineer.

**308.22 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Liquid Asphalt (RC-70, MC-30 or MC-70)	<a href="#">1015</a>
Portland Cement, Type I	<a href="#">1019</a>
Water	<a href="#">1070</a>

Soil or Other Designated Material - The gradation and other requirements will be specified in the contract.

The grade of liquid asphalt will be specified in the contract.

**308.22.1** It may be necessary to test samples of the material prior to mixing. If so, representative samples shall be obtained by the contractor in the presence of the engineer in time to permit delivery to the Central Laboratory for testing at least seven weeks prior to the preparation of any of the mixture on the project. The cement content to be used will be designated by the engineer.

### **308.23 Equipment.**

**308.23.1 Mixers.** Cement-treated base shall be mixed with an approved machine which may be (1) a single-pass mixer which pulverizes the material in place and mixes it with cement and water, (2) a mixer which elevates the material from a windrow into a pugmill and mixes it with cement and water, or (3) a multiple-pass rotary mixer capable of mixing to the full depth of treatment. Supplementary equipment for pulverizing the material prior to the addition of cement may be used, if needed. Machines which add water to the mixture before the cement has been mixed with the soil will not be approved.

**308.23.2 Distributors.** Except when water is applied directly through the mixer, pressurized distributors in satisfactory condition shall be used to obtain and maintain the specified moisture content of the mixture.

**308.23.3 Rollers.** Rollers shall be capable of producing the required density and finish. Tamping rollers shall have wedge or cone shaped feet, and may be propelled by a separate unit. All other types of rollers shall be self-propelled.

**308.23.4 Miscellaneous Equipment.** A spike-tooth harrow or similar device shall be used as necessary to minimize compaction planes. A broom drag shall be provided for use in final surface finishing. Miscellaneous equipment shall be propelled by pneumatic-tire vehicles.

**308.24 Field Laboratory.** When authorized by the engineer, the contractor shall provide a Type 2 Field Laboratory meeting the requirements of [Sec 601](#). Payment for the laboratory will be made as provided in [Sec 601](#).

### **308.25 Construction Requirements.**

**308.25.1 Roadbed Preparation.** Vegetation shall be removed from the material to be processed and shall be disposed of by the contractor. All portions of the roadbed, upon which the cement-treated base is to be constructed, shall be shaped to within a roughly compensating maximum deviation of 1/2 inch (15 mm) of the grade and cross section shown on the plans. Shaping operations may involve roadbed scarifying and shifting of material to correct excessive or deficient crown and obtain correct superelevation. Pre-pulverization of the base material may be necessary to meet the gradation requirements specified in the contract. Any soft, yielding or unsuitable subgrade shall be removed and backfilled with approved material. If such corrective action is necessary as a result of the contractor's negligence or operations, repairs shall be made at the contractor's expense.

**308.25.2 Borrow.** The contractor shall excavate the borrow area in such manner that the material obtained from the deposit complies with the requirements of the contract. The borrow area may include layers that will require mixing to produce acceptable material. It

may also contain deposits that are to be avoided as they may not be acceptable for use in the cement-treated base.

**308.25.3 Application of Cement.** The designated quantity of cement shall be uniformly distributed over the material to be treated. When cement is spread, the moisture content of the material to be processed shall not exceed the optimum moisture content of the cement-treated mixture. Cement shall be applied only to such an area that all operations can be continuous and mixing started within 3 hours of such application. Spread cement that has been displaced shall be replaced or redistributed before mixing is started. Cement shall not be applied when the material to be processed is frozen and unless the ambient temperature is at least 40 F (5 C) and rising.

**308.25.3.1** Bulk cement shall be handled and spread with equipment capable of applying the proper quantity in an approved manner. Bagged cement shall be emptied in a regular pattern and spread uniformly over the roadbed or on the windrow. Care shall be taken when spreading cement on windrows to avoid spillage on the subgrade.

**308.25.4 Mixing.** The cement, base material and water shall be mixed to form a homogeneous mixture free of segregation and having a uniform moisture content. Following moist mixing, at least 80 percent of the cement-treated mixture, exclusive of gravel, stone or lumps of bituminous material, shall pass the No. 4 (4.75 mm) sieve, and shall generally contain no clods of soil larger than one inch (25 mm). However, if clods are at or above their optimum moisture content, their maximum permissible size shall be 1 1/2 inches (38 mm), and the minimum passing the No. 4 (4.75 mm) sieve, exclusive of gravel, stone or lumps of bituminous material, shall be 70 percent. After the mixing of water, cement and base material has been completed, and during the succeeding operations, the percentage of moisture in the total material of the mixture shall not vary from the optimum moisture content as determined by the standard compaction test by more than 2.0 percentage points. The moisture content specified for the total material of the mixture shall be determined by tests on samples obtained during construction. Until such tests can be made, the optimum moisture content determined by the Central Laboratory shall be used. If the moisture content at any time during the construction exceeds the tolerance given, the mixture may be dried by aeration until the moisture content has been satisfactorily reduced. If this cannot be accomplished, the entire affected area shall be removed and replaced, or shall be corrected by mixing in an additional 50 percent of the original cement content and completing the operations, at the contractor's expense for both the processing and additional cement required.

**308.25.4.1** When multiple-pass rotary mixers are used, the cement and base material shall be mixed until a homogeneous mixture is obtained before water is added. Each application of water during the mixing operations shall be at least partially incorporated into the mixture.

**308.25.5 Compacting.** Prior to the beginning of compacting, the mixture shall be in a loose condition for its full depth. Compacting shall start immediately after mixing, and shall continue until not less than 95 percent of standard maximum density has been attained. During compacting operations, shaping and harrowing may be required to attain uniform compaction and the specified grade and cross section. No mixture shall remain undisturbed for more than 30 minutes during the mixing and compacting operations. The Standard Compaction Test and density determinations will be performed in accordance with [Sec 308.15.5.2](#). The construction of a test section and the compacting procedure shall be performed in accordance with [Sec 308.15.5.3](#).

**308.25.6 Shaping and Finishing.** Shaping and finishing of the surface of cement-treated base shall be performed in accordance with [Sec 308.15.6](#).



**308.25.6.1** The thickness of the cement-treated mixture will be determined from measurements through the finished base at approximately 500-foot (150 m) intervals. If the average thickness shown by the measurements made in one day's construction is not within 1/2 inch (15 mm) of that specified, the contractor will be required to reconstruct that day's work at the contractor's expense. The contractor will be required, at the contractor's expense, to reconstruct any areas which vary more than 3/4 inch (19 mm) from the specified thickness. Low or thin areas shall not be remedied by adding a layer to the completed work.

**308.25.7 Construction Joint.** To form a transverse construction joint, the end of a completed portion shall be cut back to a point where it meets proper grade and crown and shall be trimmed to a vertical face at right angles to the centerline for the full depth and width of the cement-treated base.

**308.25.8 Protective Cover.** The contractor shall apply a protective cover in accordance with the requirements of [Sec 308.15.7](#).

**308.26 Method of Measurement.**

**308.26.1** Measurement of cement will be made to the nearest barrel (100 kg). Measurement of bulk cement will be made by weighing (determining the mass of) each truck load on scales conforming to the requirements of [Sec 310.4.3](#). Hopper scales calibrated in a similar manner may be used in lieu of the vehicle scales. If bagged cement is used, the net weight (mass) as packaged by the manufacturer will be used for measurement.

**308.26.2** Authorized borrow material will be measured and paid for in accordance with [Sec 203](#).

**308.27 Basis of Payment.** The accepted quantities of portland cement-treated base will be paid for at the unit price for each of the pay items included in the contract. Payment for bituminous material and sand blotter for protective cover will be made in accordance with [Sec 408](#).

**308.27.1** No direct payment will be made for water used in performing this work.

## SECTION 309

### PORTLAND CEMENT CONCRETE BASE

**309.1 Description.** This work shall consist of constructing a portland cement concrete base, with or without reinforcement as specified, on a prepared subgrade in accordance with these specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer.

**309.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Emulsified Asphalt (SS-1, SS-1H, CSS-1 or CSS-1H)	<a href="#">1015</a>
Steel Wire Fabric for Concrete Pavement	<a href="#">1036.2</a>
Concrete Curing Material	<a href="#">1055</a>
Material for Joints	<a href="#">1057.1</a>

All material, proportioning, air-entraining, mixing, slump and transporting for portland cement concrete shall be in accordance with [Sec 501](#), as applicable to portland cement pavement concrete.

**309.3 Equipment.** Except as revised in [Sec 309.4](#), the equipment requirements of [Sec 502](#), including field laboratory, shall apply to the construction of this work. Approved sliding form construction methods may be used at the contractor's option.

**309.4 Construction Requirements.** The construction of concrete base shall be performed in accordance with the requirements of [Sec 502](#) with the following modifications:

(a) Belting, brooming or mechanical floating will not be required for the surface finish. The surface of the base shall be finished so that it will not vary more than 1/4 inch (6 mm) from a 10-foot (3 m) straightedge.

(b) Membrane curing shall not be used. In addition to any of the other methods permitted by [Sec 502.12](#), emulsified asphalt may be used to cure the concrete base if the surface course is to be of a bituminous type.

(c) Sawed joints may have a minimum width of 1/8 inch (3 mm) and shall not be sealed with joint sealing material.

(d) Widening an existing pavement. Either mechanical or approved manual methods may be used in preparing the subgrade and for grading and tamping the forms. The type and spacing of transverse joints will be designated in the contract. A batch-type mixer having a rated capacity of not less than 10 cubic feet (0.3 m<sup>3</sup>) of mixed concrete may be used if approved by the engineer. Either manual or mechanical methods may be used for finishing the concrete after thorough compaction by tamping or vibrating.

**309.5 Tolerance in Base Thickness.** It is the intent of these specifications that concrete base shall be constructed strictly in accordance with the thickness shown on the plans. The thickness of the concrete base will be measured, and where any base is found deficient in thickness, it may be compensated for at an adjusted unit price per square yard (square meter), or shall be removed and replaced with satisfactory concrete base.

**309.5.1** Metal plates will be placed on the subgrade at points selected by the engineer in areas where the planer has cut or leveled off the subgrade or at any points where conditions are conducive to deficient base thickness. When the surface of the base has been finished to final grade, the engineer will, for informational purposes, check the thickness of the completed base by measuring the distance from the surface of the base to the metal plates by use of a calibrated rod. The surface of the base shall be satisfactorily restored by the contractor after thickness measurements have been made. The contractor shall, if necessary, furnish a bridge to facilitate the taking of the measurements. The engineer reserves the right to core drill the finished base to determine the thickness of the base. Cores may be drilled at the same locations as rod measurements or at any other locations. The contractor may require check cores to verify thicknesses determined by the engineer, and all costs of check core drilling shall be borne by the contractor. If the check cores requested by the contractor indicate that the engineer's measurement would have erroneously resulted in deductions for, or removal of, thin base, the cost of drilling the check cores will not be charged to the contractor.

**309.5.2** The thickness of the base will be determined by average caliper measurement of cores in accordance with the procedure established by the Commission.

**309.5.3** For the purpose of determining the constructed thickness of the base, ten cores per mile (6 cores per kilometer) will be taken at random intervals in each traffic lane. In addition, cores will be taken at all locations where thickness measurements taken during construction indicate a thickness deficiency sufficient to justify a deduction from the contract unit price, or at any other locations as may be determined by the engineer. If the measurement of any core is deficient in excess of 2/10 inch (5 mm) from the plan thickness, additional cores will be taken at 20-foot (6 m) intervals parallel to centerline ahead and back of the affected location until the extent of the deficiency has been determined.

**309.5.4** It will be assumed that each core is representative of the base thickness for a distance extending one-half the distance to the next core, measured along centerline, or in the case of a beginning or ending core, the distance will extend to the end of the base section.

**309.5.5** The drilling of cores in small, narrow or irregular areas, or on projects involving less than 2500 square yards (2000 m<sup>2</sup>) of concrete base, may be waived by the engineer. In this case the designed thickness will be considered as the measured thickness.

**309.6 Method of Measurement.** Final measurement of the completed concrete base will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity. Concrete base areas will be computed to the nearest 1/10 square yard (0.1 m<sup>2</sup>).

#### **309.7 Basis of Payment.**

**309.7.1** If any core measurement of thickness is deficient, the contractor will have the option of removing and replacing the base at the contractor's expense or of leaving the base in place and receiving the following deductions in payment.

<b>Deficiency in Thickness</b>	<b>Deductions, Percent of Contract Price</b>
0 to 2/10 inch (5 mm)	None
Over 2/10 inch (5 mm) and not over 4/10 inch (10 mm)	15
Over 4/10 inch (10 mm) and not over 6/10 inch (15 mm)	60
Over 6/10 inch (15 mm)	100

**309.7.1.1** The above deductions will be applied to a section of base 20 feet (6 m) long and extending from the edge of the base to a longitudinal joint or between longitudinal joints in that section of base in which the deficient measurement was found. Deductions for deficient thickness may be entered on any estimate after the information becomes available.

**309.7.2** If base which is deficient in thickness in excess of 6/10 inch (15 mm) may in the judgment of the engineer, seriously impair traffic service of the base, the contractor will be required to remove the base and to replace it with one of a satisfactory quality and thickness which, when accepted, will be included in the pay quantity. No payment will be made for any costs incurred in the removal of the base deficient in thickness. If, in the judgment of the engineer, there is no probability of immediate failure, the engineer may allow the contractor the choice of leaving the deficient base in place and receiving no payment or of removing and replacing the base as provided herein.

**309.7.3** In removing concrete base, it shall be removed from the edge to a longitudinal joint, or between longitudinal joints, and on each side of the deficient measurement until no portion of the exposed cross sections is more than 2/10 inch (5 mm) deficient, except that there shall not be less than 10 linear feet (3 m) of base removed. If there remains less than 10 feet (3 m) of acceptable base between the section that has been removed and a transverse contraction, expansion or construction joint, the contractor shall remove the base to the joint.

**309.7.4** The contract unit price for portland cement concrete base will be considered as full compensation for all material and other items including reinforcement entering into the construction of the base, and no additional compensation will be allowed for any excess thickness. No direct payment will be made for liquid asphalt used as a curing agent.

**309.7.5** The accepted quantities of portland cement concrete base will be paid for at the contract unit price per square yard (square meter), with proper allowance made for any deductions for deficiency in thickness.

## SECTION 310

### AGGREGATE SURFACE

**310.1 Description.** This work shall consist of furnishing and placing chat, gravel or crushed stone surfacing in the quantity shown in the contract, or as directed by the engineer.

**310.2 Material.** All material shall conform to Division 1000, Material Details, and specifically to [Sec 1006](#). The type and gradation of the surfacing material to be used will be specified in the contract.

#### **310.3 Construction Requirements.**

**310.3.1** The contractor shall furnish, haul and spread surfacing material on the subgrade at the designated rate. The rate of application may be varied at the discretion of the engineer, depending upon the nature of the soil encountered in the subgrade. The contractor shall be responsible for the uniform unloading and distribution of the required quantity of material throughout each station. The subgrade shall be prepared as specified in [Sec 209](#) and any work done in reshaping the subgrade before placing surfacing material shall be at the contractor's expense. When it is determined by the engineer to be to the Commission's advantage, hauling may be done over surfacing material previously spread, otherwise, all hauling will be over the subgrade.

**310.3.2** The material shall be deposited on one shoulder on tangents and on the high shoulder of curves. Material shall be spread to a uniform thickness over the subgrade within 24 hours after being deposited on the roadbed, unless the condition of the subgrade is such that additional time should elapse. Surplus material shall be left on one shoulder on tangents and on the high shoulder of curves in a neat and symmetrical windrow, leaving openings for all approaches and for the drainage of low points.

**310.3.3** After being compacted under traffic, the material shall be shaped and ruts filled by blading the roadbed as frequently as is necessary to prevent cutting through the surfacing material into the subgrade. Irregularities which develop and which are not filled by blading shall be filled by adding more material from the windrow. The material shall be shaped until it conforms to the cross section indicated in the contract, and until it is free from ruts and waves. Maintenance of the surface shall continue until acceptance is made.

**310.3.4 Stockpiling Aggregate Surfacing Material.** Material shall be stockpiled at points specified by the engineer and in the approximate quantity shown in the contract.

**310.3.5 Salvaged Surfacing.** Designated areas shall be scarified to the full depth of the existing surfacing and such material pulverized to a maximum size of approximately 2 inches (50 mm). Approximately 75 percent of the material shall be removed from the roadbed and placed in stockpiles or spread at locations designated. Salvaged surfacing material shall be maintained as free as practicable of dirt, vegetation or other objectionable material. Salvaging shall not be performed until approved by the engineer.

#### **310.4 Method of Measurement.**

**310.4.1 Measurement by Volume.** Measurement will be made in the vehicle at the point of unloading. The contractor shall strike off and level each load for inspection and checking.

Measurement will be made to the nearest 1/4 cubic yard (0.2 m<sup>3</sup>) for each load and to the nearest cubic yard (cubic meter) for the total quantity of material accepted.

**310.4.1.1** Stockpiles of salvaged surfacing material may be measured by the average end area method.

**310.4.2 Measurement by Weight (Mass).** Measurement will be made by weighing (determining the mass of) each truck load on scales conforming to the requirements of [Sec 310.4.3](#). Deduction will be made for any moisture in excess of 2 percent of the dry weight (mass) of the material. After deduction for excess moisture has been made, measurement will be made to the nearest ton (megagram) for the total tonnage (mass) of material accepted.

**310.4.3 Vehicle Scales.** Vehicle scales shall be approved by the engineer and shall conform to the requirements specified herein.

**310.4.3.1 Basis of Acceptance.** Scale acceptance shall be based on one of the following:

(a) A valid certification or seal of approval by the Missouri Department of Agriculture, Division of Weights and Measures.

(b) A valid certification or seal of approval by a State of Missouri duly appointed Sealer of Weights and Measures in cities or counties of 75,000 population or more.

(c) Certification of calibration from a commercial scale service company showing that the scale meets the requirements of these specifications. The contractor shall furnish the certification of calibration to the engineer.

(d) Calibration from zero weight (mass) through the maximum load to be applied by the application of standard weights in the presence of the engineer by the contractor's personnel. In lieu of starting the calibration at zero weight (mass), the standard weights may be applied to an unloaded truck, the weight (mass) of which has been determined on a certified scale and the calibration continued through the maximum load to be applied. Regardless of the form of acceptance, the calibration shall be within the accuracy requirements specified in [Sec 310.4.3.2](#), and the scales shall meet all requirements of these specifications.

**310.4.3.2 Scale Calibration.** Scales shall have been calibrated within the 12-month period immediately prior to any material being delivered or any time the engineer has cause to question the accuracy of the scale. Scales shall be accurate within 0.4 percent of the net load applied regardless of the location of the load on the platform. The value of the smallest unit of graduation on a scale shall be not greater than 20 pounds (10 kg). Sensitivity requirements of scales not equipped with balance indicators shall be twice the value of the minimum graduated interval on the weigh beam, or 0.2 percent of the nominal capacity of the scale, whichever is less. For scales equipped with balance indicators, the sensitivity requirement shall be the value of the minimum graduated interval on the weigh beam.

**310.4.3.3** Verification of a vehicle scale may be required by the weighing (determining the mass) of a hauling unit on another recently calibrated and certified scale.

**310.4.3.4** If equipment to be weighed (for which the mass is to be determined) is of such length that all axles cannot be weighed (that the mass cannot be determined) simultaneously, a level area of concrete or bituminous pavement shall be provided permitting those axles not on the scale platform to be on the pavement during the weighing (mass determination) operation. The approach shall be at least as wide as the platform and of sufficient length to ensure the level positioning of vehicles during weight (mass) determinations. The weighing (mass

determination) shall be performed with all brakes released. If equipment to be weighed (for which mass determination is to be made) is equipped with an air bag suspension unit on any axle, the equipment including semi-trailers or pup trailers shall be determined on vehicle scales of sufficient size to weigh (to determine the mass of) all axles of the combination simultaneously.

**310.4.3.5** All costs incurred in obtaining a certification of calibration or verification shall be borne by the contractor.

**310.5 Basis of Payment.** The accepted quantities of aggregate surface will be paid for at the unit price for each of the pay items included in the contract.

## SECTION 311

### PROCESSING AGGREGATE SURFACE

**311.1 Description.** This work shall consist of incorporating aggregate surfacing material into the top portion of the roadbed and compacting and shaping the mixture.

#### **311.2 Construction Requirements.**

**311.2.1** After the designated quantity of aggregate surfacing material has been distributed and spread uniformly over the prepared subgrade, it shall be incorporated into the upper 2 to 4 inches (50 to 100 mm) of the roadbed by the use of a blade, tiller, scarifier or disk until a uniform mixture of surfacing material and roadbed soil is attained.

**311.2.2** The mixture shall be compacted by not less than three complete coverages with a tamping-type roller and rolling shall be continued until there is no visible evidence of further consolidation. The tamping roller shall have a minimum load on each tamper of 250 pounds per square inch (18 kg/100 mm<sup>2</sup>) of tamping area. Water shall be added to or removed from the mixture as necessary, in the judgment of the engineer, to permit proper consolidation. Shaping and compacting shall be continued until a true uniform surface of proper cross section is obtained. Final rolling shall be accomplished by means of a pneumatic tire roller weighing not less than 5 tons (having a mass of not less than 4.5 kg).

**311.2.3** The compacted mixture of aggregate surfacing material and roadbed soil shall be maintained until the work has been accepted. Weak or soft spots which develop at any time in the compacted roadbed surface prior to acceptance shall be repaired with suitable material at the contractor's expense.

**311.3 Method of Measurement.** Measurement will be made to the nearest 1/10 station (5 m) as measured along the centerline of the roadbed. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**311.4 Basis of Payment.** The accepted quantity of processing aggregate surface will be paid for at the contract unit price. No direct payment will be made for water required in performing this work. Any costs involved in reducing the moisture content will be at the expense of the contractor.



# **DIVISION 400**

## ***FLEXIBLE PAVEMENTS***



## SECTION 401

### PLANT MIX BITUMINOUS PAVEMENT

**401.1 Description.** This work shall consist of a mixture of aggregate, filler if needed, and asphalt binder prepared in a stationary bituminous mixing plant in such proportions that the resulting mixture meets the grading requirements of the job-mix formula. One or more courses of the mixture shall be placed, spread and compacted in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer.

**401.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Coarse Aggregate	1002.1.1 to 1002.1.3, incl.
Fine Aggregate	1002.2
Mineral Filler	1002.3
Hydrated Lime	1002.4
Asphalt Binder, Performance Graded (PG)	1015

The grade of asphalt binder will be specified in the contract.

**401.2.1** The gradation of coarse aggregate shall be such that the total aggregate meets the mixture specified in the contract prior to being fed into the cold aggregate feeders.

**401.2.2** Screenings shall be considered coarse aggregate consisting of tough, durable particles of approved quality and shall be free from dirt or other objectionable material. The fraction passing a No. 40 (425 µm) sieve shall be non-plastic.

#### **401.3 Composition of Mixtures.**

**401.3.1 Gradation of Combined Aggregates.** The total aggregate prior to mixing with asphalt binder shall meet the mixture specified in the contract.

Sieve Size	Percent Passing by Weight (Mass)	
	BP-1	BP-2
3/4 inch (19.0 mm)	100	100
1/2 inch (12.5 mm)	80-100	95-100
No. 4 (4.75 mm)	40-65	60-90
No. 8 (2.36 mm)	30-55	40-70
No. 30 (600 µm)	10-30	15-35
No. 200 (75 µm)	4-12	4-12

**401.3.2** The combinations of material as required in this section shall meet the gradation requirements specified for the work.

**401.3.2.1** If gravel, or if flint chat as produced in the Joplin area, is used, not less than 15 percent nor more than 30 percent crushed stone screenings, or dolomite chat screenings as produced in the Southeast Missouri Lead Belt Area, or not less than 4 percent mineral filler by

weight (mass) shall be added as a separate ingredient. Screenings shall have 100 percent passing the 3/8-inch (9.5 mm) sieve.

**401.3.2.2** If crushed stone, or if dolomite chat as produced in the Southeast Missouri Lead Belt Area, is used, not less than 15 percent nor more than 30 percent natural siliceous sand, porphyry sand or flint sand of approved quality shall be added as a separate ingredient. Wet bottom boiler slag of approved quality may be used as sand.

**401.3.2.3** If porphyry is used, sand as described in [Sec 401.3.2.2](#) or mineral filler may be added to meet gradation requirements.

**401.3.2.4** With written approval of the engineer, combinations of gravel, crushed stone, dolomite chat or porphyry, or combinations of flint chat, crushed stone, dolomite chat or porphyry, may be used. Not less than 15 nor more than 30 percent sand as specified in [Sec 401.3.2.2](#) shall be added as a separate ingredient. Each size and type of aggregate shall be added as a separate ingredient. Each size and type of aggregate shall be kept separate and fed through separate calibrated cold aggregate feeders to ensure proper proportioning. No mixture will be approved which contains less than 30 percent of any one type of coarse aggregate in the combination. In addition, all plus No. 8 (2.36 mm) sieve fractions shall contain material from each type of coarse aggregate in the approved combination.

**401.3.3** The composition of the mixture shall conform to the following limits by weight (mass):

	Percent
Total Mineral Aggregate	92.0 - 96.5
Asphalt Binder	3.5 - 8.0

**401.3.4** At least 30 days prior to preparing any of the mixture on the project, the contractor shall obtain in the presence of the engineer representative samples of asphalt binder and mineral aggregates for tests. The samples of the material shall be of the size specified by the engineer and shall be submitted to the Central Laboratory for testing. The contractor shall also submit for the engineer's approval a job-mix formula for the mixture to be supplied for the project. No mixture will be accepted for use until the job-mix formula for the project is approved by the engineer. The job-mix formula shall be within the gradation range for the grade specified and shall include the type and sources of all material, the gradation of the aggregates, and the relative quantity of each ingredient and shall state a definite percentage for each fraction of aggregate. No job-mix formula will be approved which does not permit within the limits specified in [Sec 401.3.1](#) and [401.3.3](#) the full tolerances specified in [Sec 401.3.6](#) for asphalt binder and not less than 1/2 the tolerances designated for material passing the No. 8 (2.36 mm) sieve and the material passing the No. 200 (75 µm) sieve. The job-mix formula approved for the mixture shall be in effect until modified in writing by the engineer. When unsatisfactory results or other conditions make it necessary or should a source of material be changed, a new job-mix formula may be required.

**401.3.5** The engineer will make such changes in the proportions of asphalt binder and aggregates as considered necessary. The proposed mixture will be compacted and tested in the laboratory in accordance with AASHTO T 167 or AASHTO T 245 at the option of the engineer and modified as follows. The test method used shall be modified by aging the mixture for two hours, at the specified compaction temperature range of the asphalt binder, just prior to compaction of the specimens. The mixture of mineral aggregate and asphalt binder shall result in a bituminous mixture which will be durable and retain satisfactory cohesion in the presence of moisture.

**401.3.5.1** Moisture susceptibility may be tested in accordance with AASHTO T 283 or AASHTO T 165, at the option of the engineer. A minimum retained strength of 70 percent shall be obtained when tested for moisture susceptibility. If requested by the contractor, hydrated lime may be added to increase retained strength to a passing level.

**401.3.5.2** The minimum voids in the mineral aggregate (VMA) shall be as listed below. The engineer may make adjustments in the job-mix formula submitted by the contractor in order that 60 to 80 percent of the VMA are filled with asphalt binder and the ratio minus No. 200 (75  $\mu$ m) material to asphalt binder is between 0.6 and 1.2. Approved mixtures, when compacted and tested in the laboratory in accordance with AASHTO T 167 or AASHTO T 245, shall have an air void content within the range listed below, when calculated from a voidless mixture composed of the same material in like proportions.

**401.3.5.2.1** Mixtures shall have a minimum stability as listed below, when tested in accordance with AASHTO T 167.

Percent Air Voids	AASHTO T 167 Modified, Stability PSI (kPa)	Voids in Mineral Aggregate (VMA)
3.0-6.0	300 (2100)	15.0

**401.3.5.2.2** Mixtures shall have a minimum stability as listed below, when tested in accordance with AASHTO T 245. The number of blows with the compaction hammer shall be 50.

Percent Air Voids	AASHTO T 245 Modified, Stability lb (N)	Voids in Mineral Aggregate (VMA)
3.0-6.0	750 (3350)	15.0

**401.3.6 Gradation Control.** In producing mixtures for the project, the plant shall be so operated that no intentional deviations from the job-mix formula are made. Mixtures as produced shall be subject to the following tolerances and controls:

(a) The total aggregate gradation shall be within the master range specified in [Sec 401.3.1](#) for the mixture specified.

(b) The maximum variation from the approved job-mix formula shall be within the following tolerances:

Passing No. 8 (2.36 mm) sieve	$\pm 5.0$ percentage points
Passing No. 200 (75 $\mu$ m) sieve	$\pm 2.0$ percentage points

(c) The quantity of asphalt binder introduced into the mixer shall be that quantity specified in the job-mix formula. No change may be made in the quantity of asphalt binder specified in the job-mix formula without written approval of the engineer. The quantity of asphalt binder determined by calculation or tests on the final mixture shall not vary more than  $\pm 0.5$  percentage point from the job-mix formula.

**401.3.7** The gradation of the aggregate will be determined from samples taken from the hot bins on batch type or continuous mixing plants or from the composite cold feed belt on drum mix plants. Batch-type or continuous mixing plants shall have a screening unit which

separates the usable heated aggregate into at least two sizes. One of the aggregate bin sizes produced by the screening unit shall contain not more than 10 percent by weight (mass) retained on the No. 4 (4.75 mm) sieve.

**401.3.8 Commercial Mixture.** If designated in the contract that an approved commercial mixture may be used, the contractor shall, at least seven days prior to the desired time of use, furnish a statement setting out the source and characteristics of the mixture the contractor proposes to furnish. The statement shall include: (1) the types and sources of aggregates, percentage range of each and range of combined gradation; (2) the percent and grade of asphalt binder; and (3) the mixing time and range of mixture temperature. The plant shall be designed and operated to produce a uniform, thoroughly mixed material free from segregation. It will not be necessary for the plant to meet the requirements of [Sec 401.6](#). A field laboratory will not be required. If the proposed mixture and plant are approved by the engineer, the component material and the mixture delivered will be accepted or rejected by visual inspection. The supplier shall furnish with the first truck load of each day's production, a certification in triplicate that the material and mixture delivered are in conformance with the contractor's approved proposal. Upon completion of the work, plant certification in triplicate shall be furnished by the supplier for the total quantity delivered. The mixture shall be transported and placed in accordance with the requirements specified in [Sec 401.8](#) through [401.13](#) and shall be compacted as specified in [Sec 401.12](#).

**401.3.8.1** Without specific contract designation, an approved commercial mixture meeting the requirements of [Sec 401.3.8](#) may be used in lieu of plant mix bituminous pavement mixtures for work that is considered temporary construction and is to be maintained at the contractor's expense. Temporary construction is work that is to be removed prior to completion of the contract. In addition, an approved commercial mixture may be used for the 2-foot (600 mm) wide shoulder edge strip adjacent to the traveled way.

**401.4 Field Laboratory.** The contractor shall provide a Type 3 Field Laboratory meeting the requirements of [Sec 601](#). No direct payment will be made for providing the laboratory.

### **Construction Requirements**

**401.5 Weather Limitations.** Bituminous mixtures shall not be placed (1) when either the air temperature or the temperature of the surface on which the mixture is to be placed is below 50 F (10 C), (2) on any wet or frozen surface, (3) when weather conditions prevent the proper handling or finishing of the mixture, or (4) between October 1 and April 1 except when authorized by the engineer. Placement within these dates will be permitted only when it is to the Commission's advantage to do so. Temperatures are to be obtained in accordance with MoDOT Test Method T20.

**401.6 Bituminous Mixing Plants.** Bituminous mixing plants and preparation of material and mixtures shall conform to the requirements of [Sec 404](#).

**401.7 Subgrade Preparation.** The subgrade upon which bituminous mixture is to be placed shall be prepared in accordance with [Sec 209](#) and tacked or primed, as specified in the contract, in accordance with [Sec 407](#) or [408](#), as applicable.

**401.8 Hauling Equipment.** Trucks used for hauling bituminous mixtures shall comply with the requirements of [Sec 404](#).

**401.9 Spreading.** The base course, primed surface or preceding course or layer shall be cleaned of all dirt, packed soil or any other foreign material prior to spreading the bituminous mixture. When placed on the roadbed, the mixture shall have a temperature of not less than

260 F (127 C). It shall be spread with an approved spreading and finishing machine in the number of layers and in the quantity required to obtain the compacted thickness and cross section shown on the plans. The paver shall be operated at a speed that will give the best results. The rate of delivery of the mixture to the paver shall be coordinated so as to provide, where practicable, a uniform rate of placement without intermittent operation of the paver. The compacted thickness of a single layer shall not exceed 2 inches (50 mm) for the surface course and 4 inches (100 mm) for the leveling course. The total thickness of the 2-foot (600 mm) wide shoulder edge strip adjacent to the traveled way may be placed in a single layer. On small areas and areas which are inaccessible to mechanical spreading and finishing equipment, the mixture may be spread and finished by hand methods when permitted by the engineer.

**401.9.1** The mixture shall be spread without tearing the surface and struck off so that the surface is smooth and true to cross section, free from all irregularities and of uniform density throughout. Care shall be used in handling the mixture to avoid segregation. Areas of segregated mixture shall be removed and replaced with suitable mixture. The outside edges of the pavement shall be constructed to an angle of approximately 45 degrees with the surface of the roadbed. The outside edge alignment shall be uniform and any irregularities shall be corrected by adding or removing mixture before compacting.

**401.9.2 Spot Wedging and Leveling Course.** Leveling course, consisting of a layer of variable thickness used to eliminate irregularities in the existing surface, shall be spread to the desired grade and cross section. Rigid control of the placement thickness of the leveling course will be required. Spot wedging operations over small areas, with feather-edging at high points and ends of spot areas, may be required prior to placing the leveling course. The use of an approved finishing machine will be required on the spot wedging and the leveling course, except that the spreading of the spot wedging with a blade grader will be permitted if results indicate the mixture is practically free from segregation.

**401.10 Joints.** Longitudinal and transverse joints shall be carefully made and well bonded. Transverse joints shall be formed by cutting back on the previous run so as to expose the full depth of the layer. When a transverse vertical edge is to be left and opened to traffic, a temporary depth transition shall be built as approved by the engineer. A single lane of any layer shall not be constructed to a length for which the adjacent lane cannot be completed the succeeding operating day. The longitudinal joints in one layer shall offset those in the layer immediately below by approximately 6 inches (150 mm); however, the joints in the final layer shall be at the lane lines of the traveled way, except that the placement width shall be adjusted such that pavement marking shall not fall on a longitudinal joint.

**401.11 Surfaced Approaches.** At locations designated in the contract or as specified by the engineer, approaches shall be primed in accordance with [Sec 408](#) and surfaced with a plant mix bituminous mixture. The bituminous surface shall be placed in accordance with the details shown on the typical section or as specified by the engineer. Approaches shall not be surfaced until after the surface course adjacent to the entrance is completed. No direct payment will be made for any work required to condition and prepare the subgrade on the approaches.

**401.12 Compaction.** Rolling shall begin after spreading the mixture as soon as it will bear the weight (mass) of the roller without undue displacement. All rollers shall be in satisfactory condition capable of reversing without backlash, and steel wheel rollers shall be equipped with scrapers. Rollers shall have a system for moistening each roll or wheel. The compacted mixture shall have a density of not less than 95 percent of that obtained by the laboratory compaction of a specimen made in the proportions of the approved mixture. Density will be

determined by the direct transmission nuclear method in accordance with MoDOT Test Method T41 or by a specific gravity method.

**401.12.1** In lieu of roller and density requirements, mixtures used for shoulders, temporary by-passes to be maintained at the expense of the contractor, and areas where a commercial mixture is used shall be thoroughly compacted by at least three complete coverages over the entire area with a pneumatic tire roller not less than 10 tons in weight (10 Mg in mass), a tandem-type steel wheel roller not less than 10 tons in weight (10 Mg in mass) or an approved vibratory roller. Rolling shall be performed at proper time intervals on each layer and shall be continued until there is no visible evidence of further consolidation and until all roller marks are eliminated.

**401.13 Surface Tolerances.** The finished courses shall have the nominal thickness shown on the plans and shall be substantially free from waves or irregularities. The final riding surface, except on medians and similar areas, shoulders, and temporary by-passes shall not vary from a 10-foot (3 m) straightedge, applied parallel to the centerline, by more than 1/8 inch (3 mm). At transverse construction joints, the surface of all other layers shall not vary from the 10-foot (3 m) straightedge by more than 1/4 inch (6 mm). Surfaces exceeding these tolerances shall be re-rolled, replaced or otherwise corrected in a manner satisfactory to the engineer.

**401.13.1** The surface of the mixture after compaction shall be smooth and true to the established crown and grade. Any mixture showing an excess of asphalt binder or that becomes loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced with satisfactory mixture, which shall be immediately compacted to conform with the surrounding area.

**401.14 Testing Pavement.** During construction, the engineer will make as many tests as are necessary to ensure that the course is being constructed of proper thickness and composition. The contractor shall cut samples of the compacted mixture from any course at locations designated by the engineer and shall deliver them to the field laboratory in good condition. Samples may be obtained by either sawing with a power saw or by drilling 4-inch (100 mm) diameter cores. Each sawed sample shall consist of a single piece of the pavement of the size designated by the engineer but not larger than 12 inches (300 mm) square. Each cored sample shall consist of four cores. All samples shall be taken the full depth of the layer to be tested and shall consist of an undisturbed portion of the compacted mixture. The surface from which samples have been taken shall be restored by the contractor not later than the next day of plant operation.

**401.14.1** After construction is complete, the engineer will require samples to ensure that the total thickness of the completed pavement is acceptable. The contractor shall obtain samples for total compacted thickness of all layers, including any bituminous base or leveling courses, at locations designated by the engineer. Each sample shall consist of one 4-inch (100 mm) diameter core taken the full depth of bituminous construction. The surface from which samples have been taken shall be restored by the contractor within 48 hours using an approved commercial or "cold patch" mixture acceptable to the engineer.

**401.15 Traffic Striping.** If the contractor's work has obliterated the existing traffic striping on resurfacing projects open to through traffic, and the surface course has not been completed at the time work is suspended for any extended period, temporary striping will be placed by the Commission when necessary in the judgment of the engineer. A deduction of an amount based on \$75.00 for each lane mile (\$47.00 for each lane kilometer) actually striped, measured to the nearest 0.1 mile (0.1 km), of uncompleted pavement surface requiring striping will be made from money due the contractor.



**401.16 Method of Measurement.** The weight (mass) of the mixture will be determined from the batch weights (masses) if a batch-type plant is used, and will be determined by weighing (by determining the mass of) each truck load on scales conforming to the requirements of [Sec 310.4.3](#) if other types of plants are used.

**401.16.1** Measurement of asphalt binder, to the nearest 0.1 ton (0.1 Mg) for the total tonnage used in the accepted work, will be determined by the use of the job-mix formula applied to the weight (mass) of accepted mixture of mineral aggregate and asphalt binder.

**401.16.2** Measurement of the weight (mass) of mineral aggregate, to the nearest ton (megagram), will be determined by subtracting the weight (mass) of the asphalt binder from the weight (mass) of the mixed mineral aggregate and asphalt binder.

**401.17 Basis of Payment.** The accepted quantities of plant mix bituminous pavement will be paid for at the unit price for each of the pay items included in the contract. Payment for obtaining and delivering samples of compacted mixture from the pavement and replacing the surface will be made at \$75.00 per sample.

## SECTION 402

### PLANT MIX BITUMINOUS SURFACE LEVELING

**402.1 Description.** This work shall consist of a mixture of aggregate, filler if needed, and asphalt binder prepared in a stationary bituminous mixing plant in such proportions that the resulting mixture meets the grading requirements of the job-mix formula. The material shall be spread in one course. There will be no spot wedging required.

**402.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Coarse Aggregate	<a href="#">1002.1.1</a> to <a href="#">1002.1.3</a> , incl.
Fine Aggregate	<a href="#">1002.2.1</a>
Mineral Filler	<a href="#">1002.3</a>
Asphalt Binder, Performance Graded (PG)	<a href="#">1015</a>

The grade of asphalt binder will be specified in the contract.

**402.2.1** The gradation of coarse aggregate shall be such that the total aggregate meets the gradation requirements specified for the work prior to being fed into the cold aggregate feeders.

**402.2.2** The contractor may furnish wet bottom boiler slag of approved quality in lieu of coarse aggregate specified in [Sec 402.2](#). If wet bottom boiler slag is used, it shall meet the requirements for coarse aggregate except that the percentage of wear specified in [Sec 1002.1.1](#) shall not apply.

#### **402.3 Composition of Mixture.**

**402.3.1 Gradation of Combined Aggregates.** The total aggregate for mixtures other than those containing wet bottom boiler slag in lieu of coarse aggregate, at the time of mixing with asphalt binder shall meet the following gradation requirements:

Sieve Size	Percent Passing by Weight (Mass)
3/4 inch (19.0 mm)	100
1/2 inch (12.5 mm)	95-100
No. 4 (4.75 mm)	60-90
No. 8 (2.36 mm)	40-70
No. 30 (600 µm)	15-35
No. 200 (75 µm)	4-12

**402.3.1.1** The total aggregate for mixtures containing wet bottom boiler slag in lieu of coarse aggregate, at the time of mixing with asphalt binder shall meet the following gradation requirements:

<b>Sieve Size</b>	<b>Percent Passing by Weight (Mass)</b>
1/2 inch (12.5 mm)	100
No. 4 (4.75 mm)	90-100
No. 8 (2.36 mm)	65-95
No. 30 (600 $\mu$ m)	20-40
No. 200 (75 $\mu$ m)	3-10

**402.3.2** The combinations of material as required in this section shall meet the gradation requirements specified for the work.

**402.3.2.1** If gravel, wet bottom boiler slag or flint chat as produced in the Joplin area is used, not less than 15 percent nor more than 30 percent crushed stone screenings, or dolomite chat screenings as produced in the Southeast Missouri Lead Belt Area, or not less than 4 percent mineral filler by weight (mass), shall be added as a separate ingredient. Screenings shall consist of tough durable particles of approved quality, shall be free from dirt or other objectionable material and shall have 100 percent passing the 3/8-inch (9.5 mm) sieve.

**402.3.2.2** If crushed stone, or if dolomite chat as produced in the Southeast Missouri Lead Belt area is used, not less than 15 percent nor more than 30 percent natural siliceous sand, porphyry sand or flint sand of approved quality shall be added as a separate ingredient. Wet bottom boiler slag of approved quality may be used as sand. Sand shall have 100 percent passing the 3/8-inch (9.5 mm) sieve and not more than 8 percent passing the No. 200 (75  $\mu$ m) sieve.

**402.3.2.3** If porphyry is used, sand as described in [Sec 402.3.2.2](#) or mineral filler may be added to meet gradation requirements.

**402.3.2.4** With written approval of the engineer, combinations of gravel, crushed stone, dolomite chat or porphyry, or combinations of flint chat, crushed stone, dolomite chat or porphyry may be used. Not less than 15 nor more than 30 percent sand as specified in [Sec 402.3.2.2](#) shall be added as a separate ingredient. Each size and type of aggregate shall be kept separate and fed through separate calibrated cold aggregate feeders to ensure proper proportioning. No mixture will be approved which contains less than 30 percent of any one type of coarse aggregate in the combination. In addition, all plus No. 8 (2.36 mm) sieve fractions shall contain material from each type of coarse aggregate in the approved combination.

**402.3.3** The composition of mixtures other than those containing wet bottom boiler slag in lieu of coarse aggregate shall conform to the following limits by weight (mass):

	<b>Percent</b>
Total Mineral Aggregate	92.0 - 96.5
Asphalt Binder	3.5 - 8.0

**402.3.3.1** The composition of mixtures containing wet bottom boiler slag in lieu of coarse aggregate shall conform to the following limits by weight (mass):

	<b>Percent</b>
Total Mineral Aggregate	91.0 - 95.0
Asphalt Binder	5.0 - 9.0

**402.3.4** At least 30 days prior to preparing any of the mixture on the project, the contractor shall obtain in the presence of the engineer representative samples of asphalt binder and mineral aggregates for tests. The samples of the material shall be of the size specified by the engineer and shall be submitted to the Central Laboratory for testing. The contractor shall also submit for the engineer's approval a job-mix formula for the mixture to be supplied for the project. No mixture will be accepted for use until the job-mix formula for the project is approved by the engineer. The job-mix formula shall be within the gradation range for bituminous surface leveling and shall include the type and sources of all material, the gradations of the aggregates and the relative quantity of each ingredient and shall state a definite percentage for each fraction of aggregate. No job-mix formula will be approved which does not permit within the limits specified in [Sec 402.3.1](#), at least 1/2 the tolerance specified in [Sec 402.3.6](#) for material passing the No. 200 (75 µm) sieve. The job-mix formula approved for the mixture shall be in effect until modified in writing by the engineer. When unsatisfactory results or other conditions make it necessary or should a source of material be changed, a new job-mix formula may be required.

**402.3.5** The engineer will make such changes in the proportions of asphalt binder and aggregates as considered necessary. The proposed mixture will be compacted and tested in the laboratory in accordance with AASHTO T 167 or AASHTO T 245, at the option of the engineer and modified as follows. The test method used shall be modified by aging the mixture for two hours, at the specified compaction temperature range of the asphalt binder, just prior to compaction of the specimens. The mixture of mineral aggregate and asphalt binder shall result in a bituminous mixture which will be durable and retain satisfactory cohesion in the presence of moisture. Chemical additives approved by the engineer may be made to the asphalt binder or to the mixture.

**402.3.6 Gradation Control.** In producing mixture for the project, the plant shall be operated so that no intentional deviations from the job-mix formula are made. Mixture as produced shall be subject to the following tolerances and control:

(a) The total aggregate gradations shall be within the master range specified in [Sec 402.3.1](#).

(b) Material passing the No. 200 (75 µm) sieve shall not vary from the job mix formula by more than ±2.0 percentage points.

(c) The quantity of asphalt binder introduced into the mixer shall be that quantity specified in the job-mix formula. No change may be made in the quantity of asphalt binder specified in the job-mix formula without written approval of the engineer. The quantity of asphalt binder determined by calculation or tests on the final mixture shall not vary more than ±0.5 percentage point from the job-mix formula.

**402.3.7** The gradations of the total aggregate will be determined from samples taken from the hot bins on the batch-type plants or from hot bins or combined hot aggregate flow on continuous mixing plants or from the combined cold feed on dryer-drum plants.

**402.4 Field Laboratory.** The contractor shall provide a Type 3 Field Laboratory meeting the requirements of [Sec 601](#). No direct payment will be made for providing the laboratory.

### **Construction Requirements**

**402.5 Weather Limitations.** Bituminous mixtures shall not be placed (1) when either the air temperature or the temperature of the surface on which the mixture is to be placed is below 50 F (10 C), (2) on any wet or frozen surface, (3) when weather conditions prevent the proper

handling or finishing of the mixture, or (4) between October 1 and April 1 except when authorized by the engineer. Placement within these dates will be permitted only when it is to the Commission's advantage to do so. Temperatures are to be obtained in accordance with MoDOT Test Method T20.

**402.6 Bituminous Mixing Plants.** Bituminous mixing plant and preparation of material and mixtures shall conform to the requirements of [Sec 404](#).

**402.7 Subgrade Preparation.** The subgrade upon which the bituminous mixture is to be placed shall be tacked as specified in the contract, in accordance with [Sec 407](#).

**402.8 Hauling Equipment.** Trucks used for hauling bituminous mixtures shall comply with the requirements of [Sec 404](#).

**402.9 Spreading.** The existing surface shall be cleaned of all dirt, packed soil or any other foreign material prior to spreading the bituminous mixture. When placed on the roadbed, the mixture shall have a temperature of not less than 260 F (127 C). It shall be spread with an approved spreading and finishing machine and in the quantity required to obtain the compacted thickness and cross section shown on the plans. The paver shall be operated at a speed that will give the best results. The rate of delivery of the mixture to the paver shall be coordinated so as to provide, where practicable, a uniform rate of placement without intermittent operation of the paver. On small areas, and on areas which are inaccessible to mechanical spreading and finishing equipment, the mixture may be spread and finished by hand methods when permitted by the engineer.

**402.9.1** The mixture shall be spread without tearing the surface and struck off so that the surface is smooth and true to cross section, free from all irregularities and of uniform density throughout. Care shall be used in handling the mixture to avoid segregation. Areas of segregated mixture shall be removed and replaced with suitable mixture. The outside edges of the pavement shall be constructed to an angle of approximately 45 degrees with the surface of the roadbed. The outside edge alignment shall be uniform and any irregularities shall be corrected by adding or removing mixture before compacting.

**402.10 Joints.** Longitudinal and transverse joints shall be carefully made and well bonded. Transverse joints shall be formed by cutting back on the previous run so as to expose the full depth of the layer. When a transverse vertical edge is to be left and opened to traffic, a temporary depth transition shall be built as approved by the engineer. A single lane of any layer shall not be constructed to a length for which the adjacent lane cannot be completed on the succeeding operating day. The longitudinal joint shall be at the lane lines of the traveled way except that the placement width of bituminous surface may be adjusted such that temporary raised pavement markers will not fall on a longitudinal joint.

**402.11 Compaction.** The mixture shall be thoroughly compacted by at least three complete coverages over the entire area with either a pneumatic tire roller or a tandem-type steel wheel roller each weighing (having a mass of) not less than 10 tons (9 Mg). All rollers used shall be in satisfactory condition, capable of reversing without backlash, and steel wheel rollers shall be equipped with scrapers. Rollers shall have a system for moistening each roll or wheel. Rolling shall begin as soon after spreading the mixture as it will bear the weight (mass) of the roller without undue displacement. Final rolling shall be done by the steel wheel roller. Rolling shall be performed at proper time intervals and shall be continued until there is no visible evidence of further consolidation and until all roller marks are eliminated.

**402.12 Surface Condition.** The surface of the mixture after compaction shall be smooth and uniform. Any mixture showing an excess of asphalt binder or that becomes loose and broken,

mixed with dirt, or is in any way defective shall be removed and replaced with satisfactory mixture, which shall be immediately compacted to conform with the surrounding area.

**402.13 Hauling Over Completed Surface.** Hauling of plant mix bituminous mixture over any completed portion of the project will not be permitted.

**402.14 Method of Measurement.** The weight (mass) of the mixture will be determined from the batch weights (masses) if a batch-type plant is used; and will be determined by weighing (by determining the mass of) each truck load on scales conforming to the requirements of [Sec 310.4.3](#) if other types of plants are used.

**402.14.1** Measurement of asphalt binder, to the nearest 0.1 ton (0.1 Mg) for the total tonnage (quantity) used in the accepted work, will be determined by the use of the job-mix formula applied to the weight (mass) of accepted mixture of mineral aggregate and asphalt binder.

**402.14.2** Measurement of the weight (mass) of mineral aggregate, to the nearest ton (megagram), will be determined by subtracting the weight (mass) of the asphalt binder from the weight (mass) of the mixed mineral aggregate and asphalt binder.

**402.15 Basis of Payment.** The accepted quantities of plant mix bituminous surface leveling will be paid for at the unit price for each of the pay items included in the contract.

## SECTION 403

### ASPHALTIC CONCRETE PAVEMENT

**403.1 Description.** This work shall consist of a mixture of aggregate, filler if needed, admixture if required and asphalt binder prepared in a stationary bituminous mixing plant. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that the resulting mixture meets the grading requirements, within specified tolerances, of the job-mix formula. The mixture shall be placed in one or more courses on a prepared base or underlying course in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans, or established by the engineer.

**403.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Coarse Aggregate	<a href="#">1002.1</a>
Fine Aggregate	<a href="#">1002.2</a>
Mineral Filler	<a href="#">1002.3</a>
Hydrated Lime	<a href="#">1002.4</a>
Asphalt Binder, Performance Graded (PG)	<a href="#">1015</a>
Fiber Additive	<a href="#">1071</a>

The grade of asphalt binder will be specified in the contract.

#### 403.3 Composition of Mixtures.

**403.3.1** Prior to mixing with asphalt binder the total aggregate, including filler if needed, shall meet the following gradation for the type of mixture specified in the contract:

TABLE I			
Percent Passing by Weight (Mass)			
Sieve Size	Type I-B	Type A, I-C, LP & LS	Stone Mastic Asphalt (SMA)
1 inch (25.0 mm)	100	----	----
3/4 inch (19.0 mm)	80-100	100	100
1/2 inch (12.5 mm)	60-85	90-100	85-95
3/8 inch (9.5 mm)	50-75	60-90	75 max.
No. 4 (4.75 mm)	35-55	40-65	20-28
No. 8 (2.36 mm)	25-40	25-45	16-24
No. 16 (1.18 mm)	15-30	18-35	----
No. 30 (600 µm)	10-20	12-25	12-16
No. 50 (300 µm)	6-15	7-19	12-15
No. 100 (150 µm)	4-12	4-11	----
No. 200 (75 µm)	2-7	2-7	8-10

**403.3.2** In addition to other requirements, material for stone mastic asphalt (SMA) mixtures shall meet the following.

**403.3.2.1** Coarse aggregates shall consist of crushed limestone and either porphyry or steel slag, all meeting the quality requirements of [Sec 1002](#) except as follows. The Los Angeles

abrasion, when tested in accordance with AASHTO T 96, shall not exceed 40 percent based on preliminary ledge approval and the final product. The amount of flat and elongated particles, measured on material retained on a No. 4 (4.75 mm) sieve, shall not exceed 20 percent based on a 3:1 ratio nor 5 percent based on a 5:1 ratio. The percent absorption, when tested in accordance with AASHTO T 85 shall not exceed 3.5 percent based on a final product. The limestone may be furnished in one fraction and shall generally pass the 1/2 inch (12.5 mm) sieve and shall have a minimal amount passing the No. 4 (4.75 mm) sieve. Porphyry or steel slag shall be furnished in two or more fractions.

**403.3.2.2** Fine aggregate shall consist of 100 percent crushed, manufactured sand meeting [Sec 1002.2](#) except the gradation on the No. 4 (4.75 mm) sieve shall be modified to 70-100 percent passing.

**403.3.2.3** Portland cement shall not be used as mineral filler.

**403.3.2.4** A fiber additive shall be utilized as a stabilizer. Fibers provided in loose form shall be in plastic bags suitable for dissolving in the mixture or fibers may be mechanically blown into the plant. Pelletized fibers may be approved provided the fibers can be uniformly distributed by the end of the plant mixing process and provided any additive used to form the pellets does not affect the final product. The dosage rate for fibers shall not be less than 0.3 percent by weight (mass) of the total mix for cellulose and not less than 8 percent of the binder weight (mass) for mineral fibers.

**403.3.3** The total aggregate for Type A mixtures shall contain approximately 80 percent of an approved crushed porphyry rock. Either natural or manufactured fine aggregate may be used in Type A mixtures. The percentage to be used will be specified by the engineer at the time the job-mix is approved.

**403.3.4** The total aggregate for Type I-B and I-C mixtures shall contain not less than 85 percent crushed material. Natural fine aggregate shall be limited to a maximum of 15 percent of the total aggregate in Type I-B and I-C mixtures. The engineer will adjust quantities of the various components of the mixture as necessary to obtain the required characteristics of the mixture.

**403.3.5** The total aggregate for limestone-porphyry (LP) mixtures shall contain approximately 60 percent by weight (mass) of plus No. 8 (2.36 mm) material. At least 50 percent by volume of the plus No. 8 (2.36 mm) material shall be from crushed porphyry as specified in [Sec 1002.1](#). Depending on the actual gradation of porphyry aggregate furnished, the amount of crushed porphyry required will vary. The actual percentage of required material will be designated by the engineer at the time the job mix is approved but at least 40 percent by weight (mass) of crushed porphyry will be required. Either natural or manufactured fine aggregate may be used in Type LP mixtures. The cold aggregate feeders shall be controlled to ensure proper proportioning of the various aggregate fractions in the mix.

**403.3.6** Limestone-steel slag (LS) mixtures shall contain approximately 60 percent by weight (mass) of plus No. 8 (2.36 mm) material. At least 50 percent by volume of the plus No. 8 (2.36 mm) material shall be from crushed steel slag as specified in [Sec 1002.1](#). Depending on the actual gradation of steel slag furnished, the amount of crushed steel slag required will vary. The actual percentage of required material will be designated by the engineer at the time the job mix is approved but at least 50 percent by weight (mass) of crushed steel slag will be required. Either natural or manufactured fine aggregate may be used in Type LS mixtures. The cold aggregate feeders shall be controlled to ensure proper proportioning of the various aggregate fractions in the mix.



**403.3.7** No mixture shall contain more than 10 percent by weight (mass) of chat sand produced from flint chat in the Joplin area, unless otherwise permitted by the engineer.

**403.4 Job Mix Formulas.** The contractor shall obtain, in the presence of the engineer, representative samples of asphalt binder and mineral aggregates for tests. The samples of material shall be of the size specified by the engineer and shall be submitted to the Central Laboratory for testing. The contractor shall also submit for the engineer's approval, a job-mix formula for each mixture to be supplied for the project. At least 45 days prior to the contractor preparing any of the mixture on the project, the engineer shall have received both the representative samples of the job-mix material and the contractor's proposed job-mix formula. No mixture will be accepted for use until the job-mix formula for the project is approved by the engineer. The job-mix formula shall be within the master range specified for the particular type of asphaltic concrete, and shall include the type and sources of all material, the gradations of the aggregates, the relative quantity of each ingredient, and shall state a definite percentage for each sieve fraction of aggregate and for asphalt binder. Except for SMA mixtures, no job-mix formula will be approved which does not permit, within the limits of the master range, the full tolerances specified in [Sec 403.5\(b\)](#) and [\(c\)](#) for asphalt binder and for material passing the No. 200 (75 µm) sieve. The job-mix formula approved for each mixture shall be in effect until modified in writing by the engineer. When unsatisfactory results or other conditions occur, or should a source of material be changed, a new job-mix formula may be required.

**403.4.1** Moisture susceptibility may be tested in accordance with AASHTO T 283 or AASHTO T 165, at the option of the engineer. A minimum retained strength of 70 percent shall be obtained when tested for moisture susceptibility. If requested by the contractor, hydrated lime may be added to increase retained strength to a passing level.

**403.4.2** [Secs 403.4.3](#) and [403.4.4](#) do not apply to SMA mixtures. The following requirements shall apply.

**403.4.2.1** SMA mix design will be done in accordance with applicable requirements of [Sec 403](#) except as noted herein. The final proportion of the mineral aggregates, asphalt binder and fibers will be determined by the mix design. A mixture meeting the proportioning requirements for LP or LS mixtures in [Secs 403.3.5](#) or [403.3.6](#) shall be used.

**403.4.2.2** Mixtures will be tested in accordance with AASHTO T 245, 50 Blow Test Method, modified as follows. AASHTO T 245 shall be modified by aging the mixture for two hours, at the specified compaction temperature range of the asphalt binder, prior to compaction of the specimens. Mixtures shall have physical characteristics meeting the requirements as listed below when calculated from a voidless mixture composed of the same material in like proportions. The engineer may make adjustments in the job mix formula submitted by the contractor in order that a minimum of 75 percent of the VMA is filled with asphalt binder. The requirement for the ratio of minus No. 200 (75 µm) material to asphalt binder to be between 0.6 to 1.2 is waived.

Percent Asphalt Binder	6 min.
Air Voids	3.0-5.0
Voids in Mineral Aggregate (VMA)	17.0 min.

**403.4.2.3** A job mix formula may be approved which permits the combined aggregate gradation to be outside the limits of the master range when the full tolerances specified herein are applied.

**403.4.2.4** MoDOT Test Method T61, draindown test, will be performed on the mixtures prior to approving a job mix formula. The mixture shall be stabilized in such a way that the draindown of asphalt binder shall not exceed 0.3 percent by weight (mass) of mix.

**403.4.3** The minimum voids in the mineral aggregate (VMA) shall be as listed below. The engineer may make adjustments in the job-mix formula submitted by the contractor in order that 60 to 80 percent of the VMA is filled with asphalt binder and the ratio of minus No. 200 (75 µm) material to asphalt binder is between 0.6 and 1.2. Approved mixtures, when compacted and tested in the laboratory in accordance with AASHTO T 167 or AASHTO T 245, shall have an air void content within the range listed below when calculated from a voidless mixture composed of the same material in like proportions. AASHTO T 167 and AASHTO T 245 shall be modified by aging the mixture for two hours, at the specified compaction temperature range of the asphalt binder, prior to compaction of the specimens.

**403.4.3.1** Mixtures shall have a minimum stability as listed below, when tested in accordance with AASHTO T 167.

Type of Mixture	Percent Air Voids	AASHTO T 167 Modified, Stability PSI (kPa)	Voids in Mineral Aggregate (VMA)
A	4.0-7.0	500 (3500)	15.0
I-B	4.0-7.0	500 (3500)	14.0
I-C	4.0-7.0	500 (3500)	15.0
LP	4.0-7.0	500 (3500)	15.0
LS	4.0-7.0	500 (3500)	15.0

**403.4.3.2** Mixtures shall have a minimum stability as listed below, when tested in accordance with AASHTO T 245. The number of blows with the compaction hammer shall be 75. AASHTO T 245 shall be modified by aging the mixture for two hours, at the specified compaction temperature range of the asphalt binder, prior to compaction of the specimens.

Type of Mixture	Percent Air Voids	AASHTO T 245 Modified, Stability lb (N)	Voids in Mineral Aggregate (VMA)
A	3.0-5.0	2500 (11200)	15.0
I-B	3.0-5.0	2500 (11200)	14.0
I-C	3.0-5.0	2500 (11200)	15.0
LP	3.0-5.0	2500 (11200)	15.0
LS	3.0-5.0	2500 (11200)	15.0

**403.4.4** In mixtures containing rounded or uncrushed aggregate, it may be necessary for a portion of the aggregate to be a highly angular or crushed material in order to comply with the stability and other requirements. If difficulty is experienced with the aggregate combinations submitted, the engineer may designate the proportion of angular or crushed material necessary after laboratory investigations are made of the combinations proposed by the contractor.

**403.4.5** If difficulty is experienced in obtaining a satisfactory mixture with the aggregate combinations submitted, the contractor will be advised and new types or sources of material may be required by the engineer.

**403.5 Gradation Control.** In producing mixtures for the project, the plant shall be operated so that no intentional deviations from the job-mix formula are made. Mixtures as produced shall be subject to the following tolerances and controls:

(a) They shall be within the master range in [Sec 403.3.1](#) for the particular type of mixture specified.

(b) The maximum variation from the approved job-mix formula shall be within the following tolerances:

Sieve Size	Percent Points	
	All except SMA	SMA
3/4 inch (19.0 mm)	±5.0	0.0
1/2 inch (12.5 mm)	±5.0	±4.0
3/8 inch (9.5 mm)	±4.0	±4.0
No. 4 (4.75 mm)	±4.0	±3.0
No. 8 (2.36 mm)	±3.0	±3.0
No. 16 (1.18 mm)	±3.0	-.-
No. 30 (600 µm)	±3.0	±3.0
No. 50 (300 µm)	±2.0	±2.0
No. 100 (150 µm)	±2.0	-.-
No. 200 (75 µm)	±1.0	±2.0

(c) The quantity of asphalt binder introduced into the mixer shall be that quantity specified in the job-mix formula. No change may be made in the quantity of asphalt binder specified in the job-mix formula without written approval of the engineer. The quantity of asphalt binder determined by calculation or tests on the final mixture shall not vary more than ±0.3 percentage point from the approved job-mix formula.

(d) For SMA mixtures, the engineer may make adjustments to the job mix formula to lower the proportion of mineral filler content by one percent to accommodate for minus No. 200 (75 µm) material generated by the plant. The fiber proportioning and delivery system shall have an accuracy of 10 percent by weight (mass) of the material actually being measured in any given period of time.

(e) All mixtures, except SMA, shall contain a minimum of one percent hydrated lime by weight (mass) of the total aggregate. The hydrated lime shall be added during, or ahead of, the addition of the asphalt binder. If minus No. 200 (75 µm) material is needed in addition to the one percent hydrated lime to comply with gradation requirements, mineral filler shall be added. Additional hydrated lime may be used as a mineral filler.

**403.5.1** The gradation of the aggregates will be determined from samples taken from the hot bins on batch-type or continuous mixing plants or from the composite cold feed belt on drum mix plants. Batch-type or continuous mixing plants shall have a screening unit which separates the usable heated aggregate into at least three sizes. One of the bins for the aggregate sizes produced by the screening unit shall contain not more than 15 percent by weight (mass) retained on the No. 8 (2.36 mm) sieve.

**403.6** The asphaltic concrete mixture, when sampled and tested in accordance with MoDOT Test Method T53, shall not contain more than 0.5 percent moisture by weight (mass) of the mixture.

**403.7** The asphaltic concrete mixture shall not be contaminated with deleterious agents such as unburned fuel, objectionable fuel residue, or any other material not inherent to the job mix formula.

**403.8 Field Laboratory.** The contractor shall provide a Type 3 Field Laboratory meeting the requirements of [Sec 601](#). No direct payment will be made for providing the laboratory.

**403.9 Bituminous Mixing Plants.** Bituminous mixing plants and preparation of material and mixtures shall conform to the requirements of [Sec 404](#).

**403.10 Hauling Equipment.** Trucks used for hauling bituminous mixtures shall comply with the requirements of [Sec 404](#).

**403.11 Pavers.** Bituminous pavers shall be self-contained units, provided with an activated screen or strike-off assembly, heated if necessary, and capable of spreading and finishing asphaltic concrete in lane widths applicable to the specified typical sections and thicknesses shown on the plans. The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed or strike-off. For screed extensions greater than one foot (300 mm), the distribution system shall be increased accordingly. The screed or strike-off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture. When laying mixtures, the paver shall be capable of operating at forward speeds consistent with satisfactory laying of the mixture. Equipment used for shoulders and similar construction shall be capable of spreading and finishing the courses in widths shown on the plans.

**403.12 Rollers.** All rollers, vibrators or other equipment used to compact the asphaltic mixture shall be in satisfactory working condition. All rollers shall be capable of reversing without backlash, and steel wheel rollers shall be equipped with scrapers. Pneumatic tire rollers shall be self-propelled, of the oscillating-type and equipped with smooth tires of equal size, diameter and ply rating, all maintained at the same inflation pressure. The contractor shall furnish evidence regarding tire size, pressure and loading. Rollers shall have a system for moistening each wheel or roll. Rollers shall be of a size and used in sufficient numbers to achieve specified compaction. Trench rollers, vibrators and other special equipment used for compacting mixtures placed in areas inaccessible to the rollers specified, shall be of a weight (mass) and design approved by the engineer.

**403.13 Construction Requirements.**

**403.13.1 Weather Limitations.** Asphaltic concrete shall not be placed (1) when either the air temperature or the temperature of the surface on which the mixture is to be placed is below 50 F (10 C) for the surface course or below 40 F (5 C) for subsurface courses, (2) on any wet or frozen surface, (3) when weather conditions prevent the proper handling or finishing of the mixture, or (4) between October 1 and April 1 except when authorized by the engineer. Placement within these dates will be permitted only when it is to the Commission's advantage to do so. In addition, SMA mixture shall not be placed when either the air temperature or the temperature of the surface on which the mixture is to be placed is below 60 F (15 C). The contractor shall conduct operations in such a manner that all binder course asphaltic concrete is covered with surface course asphaltic concrete prior to October 1. Temperatures are to be obtained in accordance with MoDOT Test Method T20.

**403.13.2 Test Strip.** Asphaltic concrete test strips shall be provided by the contractor for each separate asphaltic concrete mixture of 2,000 tons (2,000 Mg) or greater per contract, to determine the compactive effort necessary to provide the specified density.

**403.13.2.1** Test strips shall be constructed after approval of a job mix formula and calibration of the bituminous mixing plant. Prime or tack coat, if specified, shall be applied to the

roadbed section followed by the placement of approximately 250 tons (250 Mg) or one hour's production, whichever is less, of an approved mixture in a single lane within the project limits. The paver and rollers to be used on the project shall be equivalent to the paver and rollers used to place the test strip in accordance with [Sec 403.18](#). Separate test strips shall be provided for each mix design, using the thickness specified on the typical section. If more than one thickness is used for a specified mixture, the thicker lift shall be placed in a test strip as a minimum. Test strips for subsequent lifts which incorporate a new mix design may, at the contractor's option, be placed after completion of the previous lift. Acceptable test strips shall meet density and all other specification requirements for the mixture tested.

**403.13.2.2** Density will be determined in accordance with [Sec 403.18](#) and if necessary, additional test strips shall be constructed until a rolling pattern has been established which will provide the specified density. A new test strip shall also be required whenever a change in the job mix formula occurs or unacceptable results occur. If the test strip fails to meet the specified density, it may be left in place and the material paid for at a reduced rate provided the second test strip meets the specifications. If the second test strip also fails, both test strips shall be removed. Any subsequent test strips that fail shall also be removed. Additional placement of the mixture will not be allowed until a test strip meeting specifications has been laid.

**403.13.2.3** The material in test strips approved by the engineer will be paid for at the contract unit price. All material in unacceptable test strips shall become the contractor's property and shall be removed at the contractor's expense.

**403.14 Application of Prime or Tack.** The prime or tack coat, if specified, shall be applied as set forth in [Secs 407](#) or [408](#), whichever is applicable.

**403.15 Spreading and Finishing.** The base course, primed or tacked surface, or preceding course or layer shall be cleaned of all dirt, packed soil or any other foreign material prior to spreading the asphaltic mixture. The mixture, when delivered to the spreading and finishing machine, shall have a temperature of not less than 260 F (130 C) and be within 25 F (15 C) of that specified by the engineer. If lumps are present or a crust of mixture has formed, the entire load shall be rejected. The paver shall be operated at a speed that will give the best results. The rate of delivery of the mixture to the paver shall be coordinated so as to provide, where practicable, a uniform rate of placement without intermittent operation of the paver.

**403.15.1** The thickness and width of each course shall conform to the typical section in the contract. The contractor may elect to construct each course in any number of layers; but no individual layer shall have a compacted thickness greater than 3 inches (75 mm) for Type I-B mixture, or 2 inches (50 mm) for Type A, I-C, LP, LS or SMA mixtures. These thicknesses may be increased one inch (25 mm) when used for spot wedge or leveling course.

**403.15.2** For pavements having a width of 16 to 24 feet (5 to 7 m), inclusive, the asphaltic concrete pavement shall be laid in lanes approximately one half the full width of the completed pavement and the full width completed as soon as practicable. Unless otherwise permitted, a single lane of any course shall not be constructed to a length which cannot be completed to full width of the pavement the succeeding operating day. For pavements greater than 24 feet (7.3 m) wide, single lane width construction shall be limited to one day's production and completion to full width shall be accomplished as soon as practicable.

**403.15.3** No segregation will be permitted in handling the mixture at the plant, from the truck or during spreading operations on the roadbed. All layers shall be feathered out, by hand raking if necessary, in transitioning the depth of the surface to meet present grades at bridges or ends of projects, to provide a uniform, smooth riding surface free of irregularities. Where

only the top layer of the surfacing continues across a bridge, the bottom layers shall be feathered out.

**403.15.4** If the asphaltic concrete construction consists of more than a single layer, each layer shall be compacted as specified and allowed to cool to the ambient temperature before the next layer is placed. The contractor shall keep traffic off the asphaltic concrete until it has cooled sufficiently to prevent flushing of the asphalt binder to the surface, marking or distorting the surface, or breaking down the edges and in any case, until the surface of the asphaltic concrete is 140 F (60 C) or below. The final surface layer shall be laid in the same sequence over the entire project as the previously constructed layers unless otherwise approved by the engineer.

**403.15.5** For SMA mixtures, maximum haul distance should be minimized due to the potential for asphalt binder separation from the mixture. Evidence of asphalt binder separation or draindown at delivery will be cause for rejection. SMA mixtures, when delivered to the spreading and finishing machine, shall have a temperature of not less than 290 F (143 C) and be within 25 F (10 C) of that specified by the engineer. The paver speed shall be such that delivery of mixture to the paver is continuous and so that the breakdown rollers can be maintained within approximately 200 feet (60 m) of the paver.

**403.15.6** When a [Sec 403](#) mixture is specified for the traffic lanes, the same mixture may be used for the adjacent shoulder, subject to the density requirements herein. However, no additional pay will be made for the use of Types A, LS, LP or SMA when used in lieu of Type I-C for the shoulder.

**403.16 Spot Wedging and Leveling Course.** The engineer will specify the locations and thickness of spot wedging and the thickness of leveling course to obtain the smoothest possible riding surface. This procedure may result in spot wedging operations over small areas with feather-edging at high points and ends of wedge areas. Rigid control of the placement thickness of the leveling course will be required. Leveling course, consisting of a layer of asphaltic concrete of variable thickness used to super-elevate curves and eliminate irregularities in the existing base, shall be spread uniformly to the specified profile grade and cross section. The use of an approved finishing machine will be required on the spot wedge and the leveling course except that spreading of the spot wedging with a blade grader will be permitted if results indicate the mixture is practically free from segregation and is uniformly spread and compacted. Type I-C, LP or LS mixtures, as applicable, shall be used for the spot wedging and for the leveling course.

**403.17 Blank.**

**403.18 Compaction.** After the asphaltic mixture has been spread, struck off and surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rolling. When test strips are required, the roller equipment, rolling pattern and effort used in the test strip to establish compactive effort, shall not be lessened in any manner unless a new test strip is requested by the contractor and satisfactory results are established. Rolling shall begin as soon after spreading the mixture as it will bear the weight (mass) of the roller without undue displacement. The type and number of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. A pneumatic tire roller shall be used as the initial or intermediate roller on any course placed as a wedge or leveling course. All rolling shall be completed prior to the surface temperature of the mixture decreasing to 175 F (80 C).

**403.18.1** Any displacement occurring as a result of starting, stopping or changing direction of a roller, or from other causes, shall be avoided. Areas of displacement shall be corrected at once by the use of rakes and addition of fresh mixture when required. Care shall be exercised

in rolling not to displace the line and grade of the edges of the asphaltic concrete. If necessary to prevent adhesion of the mixture to the rollers, the wheels and rolls shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted. Diesel fuel, fuel oil or other detrimental products shall not be used as wetting agents. Along forms, curbs, headers, walls and other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons or with mechanical tampers. A trench roller shall be used on depressed areas inaccessible to regular width equipment.

**403.18.2** Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced with fresh, hot mixture, which shall be compacted to conform with the surrounding area. Any area showing an excess or deficiency of asphalt binder shall be removed and replaced.

**403.18.3** Except as otherwise specified, rolling shall be continued until all roller marks are eliminated and a minimum density of 98 percent of a laboratory specimen made in the proportions of the job-mix formula in accordance with AASHTO T 167 or 96 percent of a laboratory specimen made in the proportions of the job-mix formula in accordance with AASHTO T 245, is attained. The applicable density will be determined by the engineer to correspond with the mix design test method. Density will be determined by nuclear methods in accordance with MoDOT Test Method T41 or by a specific gravity method. The direct transmission nuclear method of test will be used for Type A, I-C, LP or LS mixtures placed in layers 2 inches (50 mm) thick or thicker, and for Type I-B mixtures only when used in lieu of plant mix bituminous base in layers 2 inches (50 mm) thick or thicker. The backscatter nuclear method of test will only be used for Type A, I-C, LP or LS mixtures constructed in layers less than 2 inches (50 mm) thick.

**403.18.4** [Sec 403](#) mixtures used for surfacing medians and similar areas, shoulders adjacent to rigid or flexible pavement and shoulders adjacent to resurfaced pavement shall be compacted to the specified densities for the mixture. Once an established rolling pattern has been demonstrated to provide the required density for shoulders, at the engineer's discretion the pattern may be used in lieu of density tests provided no changes in the material, typical location or temperatures are made. Regardless of the method, density is still required and subject to testing as deemed necessary by the engineer. In lieu of roller and density requirements, temporary by-passes to be maintained at the expense of the contractor may be thoroughly compacted by at least three complete coverages over the entire area, with a tandem-type steel wheel roller weighing (having a mass of) not less than 10 tons (9 Mg). The rolling shall be performed at proper time intervals and shall be continued until there is no visible evidence of further consolidation.

**403.18.5** For SMA mixtures, rolling shall be continued until all roller marks are eliminated and density is attained. Pneumatic tire rollers shall not be used. Minimum density shall be 98.0 percent of a laboratory specimen made in the proportions of the job mix formula in accordance with AASHTO T 245, 50 blow. Density will be determined by a specific gravity method. Traffic shall be kept off of the SMA until the surface of the SMA is 140 F (60 C) or below and has cooled sufficiently to prevent flushing of the asphalt binder to the surface, marking or distorting the surface or breaking down the edges. Cores for determining the in-place density of the mixture shall be taken not later than the day following placement. In addition to any adjustments in pay due to profile, the contract unit price for the SMA mixture represented by each set of cores will be adjusted based on the following schedule:

<b>Field Density Percent of Laboratory Compacted Specimens</b>	<b>Pay Factor Percent of Contract Unit Price</b>
98.0 or greater	100.0
97.5 - 97.9	90.0
97.0 - 97.4	75.0
96.5 - 96.9	55.0
96.4 or less	0.0

No cores shall be taken later than the day following placement for any payment purposes. All mixtures with less than 96.5 percent compaction shall be removed and replaced with approved mixture.

**403.19 Joints.** Transverse joints shall be formed by any method that will produce a dense, vertical section for use when laying is resumed. When a transverse vertical edge is to be left and opened to traffic, a temporary depth transition shall be built as approved by the engineer. The joint formed when the fresh mixture is placed shall be dense, well sealed, and the grade, line and surface texture of the succeeding surface shall conform to that of the joined surface. If deemed necessary by the engineer, the transverse joint shall be painted with a light coating of liquid asphalt. Hand manipulation of the mixture is to be minimized to avoid unsightly surface texture. Placing of asphaltic mixture shall be as nearly continuous as possible and the roller shall not pass over the unprotected end unless laying of additional mixture is to be delayed for sufficient time to permit the mixture to become chilled.

**403.19.1** Longitudinal joints shall be formed by the use of an edging plate fixed on both sides of the finishing machine. These plates shall be adjustable and the outside plate shall be set at an angle of approximately 45 degrees with the surface of the roadbed and in a position that will lightly compact the mixture. The inside plate, or that placing material for the longitudinal joint, shall be normal to the roadbed. When placing the first lane, if the mixture at the longitudinal joint tends to slump, it shall be set up to a vertical edge by light compaction with the back of a rake. Care shall be taken to obtain a well bonded and sealed longitudinal joint by placing the hot mixture in a manner ensuring maximum compaction at this point. If it is deemed necessary by the engineer in properly sealing the longitudinal joint, a light coating of bituminous material shall be applied to the exposed edge before the joint is made. The minimum density of all traveled way pavement within 6 inches (150 mm) of a longitudinal joint, including the pavement on the traveled way side of the shoulder joint, shall not be less than 2.0 percent below the specified density. Once an established procedure has been demonstrated to provide the required density for longitudinal joints, at the engineer's discretion, the procedure may be used in lieu of density tests provided no changes in the material, typical location or temperatures are made. Pay adjustments due to longitudinal joint density shall apply to the full width of the traveled way pavement and shall be in addition to any other pay adjustments. Irregularities in the outside edge alignment shall be corrected by removing or adding mixture before the surface is compacted.

**403.19.2** The longitudinal joint in any layer shall offset that in the layer immediately below by approximately 6 inches (150 mm); however, the joints in the completed surfacing shall be at the lane lines of the traveled way or other required placement width outside the travel lane. The placement width shall be adjusted such that pavement marking shall not fall on a longitudinal joint.

**403.20 Surface Test.** The surface of each layer shall be substantially free from waves or irregularities. As soon as practicable, the pavement surface shall be thoroughly tested by profilographing or straightedging as indicated. Testing applicable to this specification, except



straightedging, shall be performed by the contractor in the presence of the engineer. Profilographing shall be performed on the surface course on all resurfacing work containing leveling course, coldmilling or multiple course construction as an operation to improve the original riding surface prior to placing the new surface and on the surface course of all new construction. On all other work except medians and similar areas, shoulders adjacent to rigid pavement or adjacent to resurfaced rigid pavement, and temporary bypasses, the final surface shall not vary from a 10-foot (3 m) straightedge, applied parallel to the centerline, by more than 1/8 inch (3 mm). At transverse construction joints, the surface of all other layers shall not vary from the 10-foot (3 m) straightedge by more than 1/4 inch (6 mm).

**403.20.1 Profilographing.** Profilographing is applicable to the surface of all mainline paving, auxiliary lanes, turning lanes and ramps. Specifically excluded are:

- (a) Bridge decks and their approach slabs.
- (b) Pavement on horizontal curves with centerline radius of curve less than 1000 feet (300 m) and pavement within the superelevation transition of such curves.
- (c) Pavement on vertical curves having a "K" value of less than 90 and a length less than 500 feet (150 m).
- (d) Contracts or stages of construction with less than one half mile (0.8 km) of continuous bituminous pavement.
- (e) Width transitions.
- (f) Fifty feet (15 m) in direction of travel on each side of utility appurtenances such as manholes and valve boxes.
- (g) Fifty feet (15 m) in direction of travel on each side of intersecting routes with special grade transitions.
- (h) Bituminous shoulders.

**403.20.1.1** Pavement profile shall be taken 3 feet (1 m) from and parallel to either edge of pavement or along the centerline of the lane being placed as directed by the engineer.

**403.20.1.2** Additional profiles shall be required only to define limits of areas representing deviations greater than 0.4 inch (10 mm), except as required in [Sec 403.20.6.4](#).

**403.20.1.3** A profilogram shall be made for each continuous section of 50 feet (15 m) or more for each day's placement. A section is defined where paving begins and terminates at a days work joint, a bridge or other interruptions designated by the engineer. Sections will be divided into segments of 0.1 mile (100 m) with the exception of the last segment which normally will be less than 0.1 mile (100 m).

**403.20.1.4** Individual sections shorter than 50 feet (15 m) and the last 50 feet (15 m) of any section where the contractor is not responsible for the adjoining surface, will be straightedged in accordance with [Sec 403.20.2](#).

**403.20.1.5** If there is a segment of 250 feet (75 m) or less in length at the end of a section, the profilogram for that segment shall be included in the evaluation of the adjacent segment in that section.

**403.20.1.6** If there is an independently placed section of a length between 50 and 250 feet (15 and 75 m), a profilogram shall be made for that section and included in the evaluation of the most recently placed adjacent segment.

**403.20.1.7** The contractor shall furnish the profilogram and its evaluation to the engineer. The testing shall be done by a trained operator in the presence of the engineer. The testing procedure and the evaluation of the profilogram shall be done in accordance with this specification and MoDOT Test Method T59. The profilogram and evaluation shall be furnished to the engineer not later than the end of the next working day following placement of the pavement and within two working days after corrective action.

**403.20.1.8** The engineer may also test the surface or re-evaluate the profilogram for comparison and assurance purposes. If these tests or re-evaluations indicate the contractor-furnished profilograms are not accurate within 3.0 inches per mile (45 mm/km), the engineer may test the entire project length. If the entire project length is tested, the contractor will be charged for this work at the rate of \$500.00 per lane mile (\$310.00 per lane kilometer). Furnishing inaccurate test results may result in disapproval of the operator.

**403.20.1.9** The profilogram line drawn by the profilograph will be referred to as the profile trace in this specification.

**403.20.1.10** Profile index will be calculated from the profilogram for pavements 50 feet (15 m) or more in length. The profile index is calculated by summing the vertical deviations of the profile trace above and below the dashed reference line on the transparent scale. The units of this measure are inches per mile (mm/km).

**403.20.1.11** Bumps will be separately identified. These appear as high points on the profile trace and correspond to high points or bumps on the pavement surface. They are identified by locating vertical deviations greater than 0.40 inch (10 mm) for a 25 foot (7.622 m) span, as indicated on the profile trace.

**403.20.2 Straightedging.** As soon as practicable, all segments of the pavement surface not profilographed will be thoroughly straightedged by the engineer and all variations exceeding 1/8 inch (3 mm) in 10 feet (3 m) will be plainly marked. Areas more than 1/8 inch (3 mm) high shall be removed by an approved device as listed in [Sec 403.20.6.3](#). At transverse construction joints, the surface shall not vary from the 10 foot (3 m) straightedge by more than 1/8 inch (3 mm).

**403.20.3 Equipment.** The profilograph shall be a California type as approved by the engineer. The equipment furnished shall be supported on multiple wheels having no common axle. The wheels shall be arranged in a staggered pattern such that no two wheels cross the same bump at the same time. The pavement profile is recorded from the vertical movement of a sensing wheel attached to the frame at mid-point and is in reference to the mean elevation of the 12 points of contact with the road surface established by the support wheels. The profilogram is recorded with a scale of one inch (1 mm) equals one inch (1 mm) vertically and one inch (1 mm) equals 25 feet (300 mm) longitudinally.

**403.20.4 Calibration.** All profilographs used shall be calibrated at least annually on a test section established by MoDOT. The contractor's calibration profile index shall not vary more than 2.0 inches per mile (30 mm/km) from a standard profile index produced by a MoDOT profilograph.

**403.20.4.1** Longitudinal calibration consists of pushing the profilograph over a pre-measured test distance and determining the scale factor by dividing the pre-measured test distance by the

length of the paper in inches (millimeters). This factor shall be 25, one inch equals 25 feet (300, 25 mm equals 7.622 mm). If not, the machine shall be adjusted until the scale factor is 25 (300) plus or minus 0.2 percent.

**403.20.4.2** Vertical calibration consists of sliding a pre-measured calibration block, measured to the nearest 0.01 inch (0.25 mm), under the sensing wheel while the profilograph is stationary. The measurement of the vertical trace line from the base line to the peak and return shall be the same as the calibration block. The trace line must return to the base line. No tolerance will be allowed.

**403.20.4.3** A profilograph equipped with automatic profile trace reduction capabilities shall be checked by comparing the machine's results with the results obtained by the engineer. This shall be done for the profile trace obtained on MoDOT's test section. The results and the profilogram shall be submitted to the engineer. The results of the comparison may not differ by more than 2.0 inches per mile (30 mm/km).

**403.20.4.4** The contractor shall furnish certification that the 25 foot (7.622 m) profilograph test and evaluation was conducted by an operator trained in the use of profilograph equipment and with sufficient experience to demonstrate the operator's competence.

**403.20.5 Test Procedures.** Smoothness will be tested immediately behind the finish roller by measurement with a profilograph. This device produces a profilogram of the surface tested.

**403.20.5.1** All objects and foreign material on the pavement surface shall be removed by the contractor prior to testing.

**403.20.5.2** The profilograph shall be propelled at walking speed in the paths indicated in [Sec 403.20.1.1](#) for each section of pavement. Propulsion may be provided by personnel pushing manually or by a suitable propulsion unit.

**403.20.5.3** A location indicator for lateral placement is mandatory. More than one person may be required to hold the back end of the profilograph exactly in the required path on horizontal curves except as stated in [Sec 403.20.1\(b\)](#).

**403.20.5.4** Walking speed shall be decreased if excessive spikes are encountered.

**403.20.5.5** The sensing wheel shall be lifted, rotated to take slack out of the linkage, and lowered to the starting point prior to testing.

**403.20.5.6** The actual stationing shall be noted on the profilogram at least every 200 feet (50 m). Station referencing is used to accurately locate deviations greater than 0.40 inch (10 mm).

**403.20.5.7** Both ends of the profilogram shall be labeled with the stationing, lane designation, position on the pavement, and the direction the pavement was placed. A report form furnished by the engineer shall be completed and placed with the profilogram.

**403.20.5.8** When operating the profilograph, all wheels shall be on the new pavement for which the contractor is responsible.

**403.20.6 Surface Corrections.** Bump correction or smoothness correction or both may be required.

**403.20.6.1** If an average profile index of 45.0 inches per mile (711 mm/km) for pavements having a final posted speed greater than 45 mph (70 km/h), or 65.0 inches per mile (1026 mm/km) for pavements having a final posted speed of 45 mph (70 km/h) or less, is exceeded in any daily paving operation, the paving operation will be suspended and will not be allowed to resume until corrective action approved by the engineer is taken by the contractor.

**403.20.6.2** All bumps greater than 0.40 inch (10 mm) in height over a 25-foot (7.622-meter) span, as indicated on the profile trace, shall be corrected. The corrected bumps will be considered satisfactory when measurements by the profilograph show that the bumps are 0.40 inch (10 mm) or less in height over a 25-foot (7.622-meter) span.

**403.20.6.3** Corrective action to improve the average profile index shall be accomplished either transversely or longitudinally by approved diamond grinding or other devices specifically designed to improve the profile of the riding surface. The device used must be approved by the engineer.

**403.20.6.4** After removing all individual deviations greater than 0.40 inch (10 mm) in height, additional correction shall be performed if necessary to reduce the average profile index to 30.0 inches (474 mm) or less per mile (kilometer) for pavements having a final posted speed greater than 45 mph (70 km/h), or 45.0 inches (711 mm) or less per mile (kilometer) for pavements having a final posted speed of 45 mph (70 km/h) or less. All corrective work shall be completed prior to acceptance of the segments involved. On pavement segments where corrections are necessary, additional profiles shall be made to verify that the corrections have produced an average profile index within the limits noted above.

**403.20.6.5** If the initial average profile index of any segment is less than 30.1 inches per mile (475 mm/km) for pavements having a final posted speed greater than 45 mph (70 km/h), or less than 45.1 inches per mile (712 mm/km) for pavements having a final posted speed of 45 mph (70 km/h) or less, only the areas with deviations greater than 0.40 inch (10 mm) in height shall be retested for correction verification.

**403.20.6.6** Any final lift pavement surface, which does not meet the longitudinal smoothness requirements given above, shall be repaired by the contractor to meet the requirements either by methods discussed in [Sec 403.20.6.3](#), by overlaying, or by removing and replacing, as approved by the engineer, in accordance with the following:

(a) **Approved Grinding or Milling Devices.** Individual high points in excess of 0.40 inch (10 mm), as determined by measurements of the profilograph shall be reduced by milling/grinding as provided in this section until such high points, as indicated by reruns of the profilograph, do not exceed 0.40 inch (10 mm). After milling/grinding has been completed to reduce individual high points, additional milling/grinding shall be performed as necessary to reduce the average profile index to 30.0 inches (474 mm) or less per mile (kilometer) for pavements having a final posted speed greater than 45 mph (70 km/h), or 45.0 inches (711 mm) or less per mile (kilometer) for pavements having a final posted speed of 45 mph (70 km/h) or less. Additional milling/grinding shall be performed as necessary to produce a uniform cross section. All milled areas shall be neat and of uniform surface appearance.

(b) **Overlaying.** When an additional lift of asphaltic concrete is used to repair a rough pavement, it shall meet all the requirements of the preceding specifications. The overlay lift shall extend for the full width of the underlying pavement surface and have a finished compacted thickness sufficient to correct the roughness and produce a final surface meeting specifications. If the overlay does not meet the longitudinal smoothness requirement,

a second overlay will not be allowed. The repairs to an overlay not meeting smoothness requirement shall be made by the contractor in accordance with the specifications.

(c) Removing and Replacing. Where repair of rough pavement is made by removing and replacing the material, replacement shall meet the preceding specifications.

**403.20.6.7** The final texture of the corrected asphaltic concrete pavement shall be such that the texture is comparable to adjacent sections that do not require correcting.

**403.21 Testing Pavement.** The finished courses shall have the nominal thickness shown on the plans. Tests will be made to ensure that each course is being constructed of proper thickness, composition and density. The contractor shall cut samples from any layer of the compacted mixture at locations designated by the engineer. The sample shall be cut and delivered to the engineer no later than the end of the next calendar day following the laydown operation. If the sample is not cut and delivered as stated, the asphaltic laydown operation may be suspended and a deduction of 5 percent per day of the contract unit price of the representative material may be applied, until samples are cut and delivered to the engineer. Samples may be obtained by either sawing with a power saw or by drilling 4-inch (100 mm) diameter cores. Each sawed sample shall consist of a single piece of the pavement of the size designated by the engineer, but not larger than 12 inches (300 mm) square.

**403.21.1** Each cored sample for density determination shall consist of four cores. All samples, whether sawed or cored, shall consist of an undisturbed portion of the compacted mixture removed for the full depth of the layer or course to be tested. Cores used to establish a nuclear correction factor shall be taken in a number designated by the engineer and each four cores and fraction thereof shall be considered a sample.

**403.21.2** Each sample taken for total course thickness shall consist of one 4-inch (100 mm) diameter core taken for the full depth of the course. Each sample taken for total compacted thickness shall consist of one 4-inch (100 mm) diameter core taken for the full depth of bituminous construction, including the surface course, binder course, leveling course or bituminous base course. Total thickness samples may be obtained after all bituminous construction is completed on the project and shall be taken at locations specified by the engineer.

**403.21.3** The surface from which samples have been taken shall be restored by the contractor with the mixture then being produced not later than the next day of plant operation, if construction is still active. If bituminous construction has been completed, the surface from which samples have been taken shall be restored within 48 hours with an approved commercial mixture or with cold patch mixtures acceptable to the engineer.

#### **403.22 General Requirements.**

**403.22.1 Sequence of Operations.** To reduce inconvenience to the traveling public during widening or surfacing, the contractor will not be permitted to place any final surface course until the base widening, the leveling course, and the binder course have been completed throughout the entire combination of sections, unless otherwise authorized by the engineer. The proper condition of the base widening, the leveling course and the binder course, at the time of placing the surface course, shall be the contractor's responsibility.

**403.22.2 Traffic Striping.** If the contractor's work has obliterated the existing traffic striping on resurfacing projects open to through traffic, the traffic marking shall be replaced in accordance with [Sec 620](#).

**403.22.3 Surfaced Approaches.** At locations designated in the contract or as specified by the engineer, approaches shall be primed in accordance with [Sec 408](#) and surfaced with Type I-C, LP or LS asphaltic concrete. The asphaltic concrete surface shall be placed in accordance with the details shown on the typical section or as specified by the engineer. Approaches shall not be surfaced until after the surface course adjacent to the entrance is completed. No direct payment will be made for any work required to condition and prepare the subgrade on the approaches.

**403.22.4 Filling Drain Basins.** If shown on the plans, existing drain basins shall be filled to the top of the lip with plant mix bituminous base course or asphaltic concrete from the pavement edge to the edge of the shoulder. No direct payment will be made for any difficulty or delay occasioned by this requirement.

**403.22.5 Pavement Repairs (Blow-Ups).** A blow-up will be considered that area where excessive expansion has resulted in distress to the existing pavement. Blow-ups occurring prior to the application of the tack coat on the existing surface will generally be repaired by the Commission. Blow-ups occurring after the application of the tack coat shall be repaired by the contractor by removing the distressed concrete and making replacement with asphaltic concrete mixture, thoroughly compacted.

#### **403.23 Method of Measurement.**

**403.23.1** The weight (mass) of the mixture will be determined from the batch weights (masses) if a batch-type plant is used, and will be determined by weighing (determining the mass of) each truck load on scales conforming to the requirements of [Sec 310.4.3](#) if other types of plants are used.

**403.23.2** Measurement of asphalt binder, to the nearest 0.1 ton (0.1 Mg) for the total tonnage (quantity) used in the accepted work, will be determined by the use of job-mix formula applied to the weight (mass) of accepted mixture of mineral aggregate and asphalt binder.

**403.23.3** Measurement of the weight (mass) of mineral aggregate, to the nearest ton (megagram), will be determined by subtracting the weight (mass) of the asphalt binder from the weight (mass) of the mixed mineral aggregate and asphalt binder.

#### **403.24 Basis of Payment.**

**403.24.1** Due to possible variations in the specific gravity of the aggregates, the tonnage (quantity) used may vary from the proposal quantities and no adjustment in contract unit price will be made because of such variation.

**403.24.2** Payment for obtaining and delivering samples of compacted mixture from the pavement and replacing the surface will be made at \$75.00 per sample.

**403.24.3 Payment for Pavement Repairs (Blow-ups).** Payment for removing and disposing of the broken concrete and for preparing subgrade will be made as provided in [Sec 104.3](#). Payment for furnishing, placing and compacting the asphaltic concrete replacement material will be at the contract unit price for the mixture used.

**403.24.4** The contract unit price for all mixes, except wedge or level course, shall be adjusted based on smoothness as measured on the surface course. Payment for smoothness will be based on either Table I or Table II. Table I will be used for pavements having a final posted speed greater than 45 mph (70 km/h). Table II shall be used for pavements having a final

posted speed of 45 mph (70 km/h) or less and for pavements with no posted speed limits. Constant width acceleration and deceleration lanes shall be considered as mainline pavements.

Final Profile Index, Inches Per Mile (mm/km)		Percent of Contract Price
Table I	Table II	
10.0 (158) or less		107
10.1 - 15.0 (159 - 237)	15.0 (237) or less	105
15.1 - 18.0 (238 - 284)	15.1 - 25.0 (238 - 395)	103
18.1 - 30.0 (285 - 474)	25.1 - 45.0 (396 - 711)	100
30.1 - 45.0 (475 - 711)	45.1 - 65.0 (712 - 1026)	95*
45.1 (712) or greater	65.1 (1027) or more	93*

\*Correction required.

**403.24.4.1** Smoothness incentive will be paid per section based on the profile index before bump correction. Within a section qualifying for incentive pay, any segment having a profile index requiring a reduction in contract price will not be included in incentive payment for that section.

**403.24.4.2** Segments with a profile index of 30.1 (475) or greater, Table I, or 45.1 (712) or greater, Table II, after bump correction, shall be corrected as specified in [Sec 403.20.6](#) until the profile index is 30.0 (474) or less, Table I, or 45.0 (711) or less, Table II, or at the contractor's option the segment may be removed and replaced with no additional payment. Under Table I, those segments with a profile index of greater than 30.0 (474) and less than 45.1 (712) after bump correction will receive 100 percent of contract price when reduced to 30.0 (474) or less, and those segments with a profile index of 45.1 (712) or greater before bump correction will receive 93 percent when reduced to 30.0 (474) or less. Under Table II, those segments with a profile index of greater than 45.0 (711) and less than 65.1 (1027) after bump correction will receive 100 percent of contract price when reduced to 45.0 (711) or less, and those segments with a profile index of 65.1 (1027) or greater before bump correction will receive 93 percent when reduced to 45.0 (711) or less.

**403.24.4.3** On sections where corrections are made, the pavement will be tested by the contractor to verify that corrections have produced a profile index of 30.0 (474) or less, Table I, or 45.0 (711) or less, Table II.

**403.24.4.4** The contractor will not be allowed to make corrections to increase the percent of pay when the final profile index is 30.0 (474) or less, Table I, or 45.0 (711) or less, Table II.

**403.24.4.5** If the profile index, after bump correction, is 30.1 (475) or greater, Table I, or 45.1 (712) or greater, Table II, and the contractor elects to remove and replace the segment, the contractor will be paid the percent of contract price that corresponds to the replaced segment's profile index as specified above.

**403.24.4.6** The contract unit prices for asphaltic concrete pavement will be considered as full compensation for all material entering into the construction of the pavement and for the cost of the smoothness testing.

**403.24.4.7** When paving widths are greater than the travel lane widths, profiling and payment for profiling will apply to the traffic lane design driving width only, normally 12 feet (3.6 m).

**403.24.5** Random lane coring for thickness or required lane replacement will include the full paved lane width to the longitudinal joints or edge of shoulder, whichever is first.

**403.24.6** Payment for test strips including all equipment, labor and any other work necessary to complete this item will be considered as completely covered by the contract unit price. Accepted test strips meeting density and all other specification requirements will be paid for at the contract unit price per test strip. No payment will be made for test strips required as a result of a change in the job mix formula, compaction method or equipment when initiated by the contractor or when unacceptable results occur as determined by the engineer. Test strips meeting density requirements, but fail to meet other specification requirements, may be left in place and the material paid for as determined by the engineer.



## SECTION 404

### BITUMINOUS MIXING PLANTS

**404.1 Description.** This specification covers the requirements for mixing plants and equipment used in the production of bituminous mixtures.

#### **404.2 Requirements for All Plants.**

**404.2.1 Aggregates.** Sufficient storage space shall be provided for each size of aggregate. The different aggregate sizes shall be kept separated until they have been delivered to the combined cold feed belt. The storage yard shall be maintained neat and orderly and the separate stockpiles shall be readily accessible for sampling.

**404.2.2 Asphalt Binder.** An asphalt binder storage tank shall be provided at the proportioning and mixing plant. If more than one storage tank is used to deliver asphalt binder to the proportioning unit, piping and valve arrangements shall permit material to be used from any one of the tanks without using from another at the same time.

**404.2.2.1** Each tank used for storage from which asphalt binder is delivered to the proportioning unit shall be equipped for heating the material under effective and positive control at all times to the temperature requirements set forth in [Sec 1015](#). Heating shall be by steam or oil coils, electricity, or other means such that no flame shall come in contact with the heating tank. The contractor shall furnish a tank capacity chart calculated in increments suitable for verifying quantities used during a normal production period.

**404.2.2.2** A circulating system of adequate capacity shall provide proper and continuous circulation of the asphalt binder between storage tank and proportioning units during the entire operating period. The discharge end of the circulating pipe shall be maintained below the surface of the asphalt binder in the storage tank to prevent discharging into the open air. All pipe lines and fittings shall be steam or oil-jacketed or otherwise properly insulated to prevent heat loss.

**404.2.2.3** The contractor shall provide in the asphalt binder feed lines connecting the plant storage tanks to the proportioning or injection system a sampling outlet consisting of a valve installed in such manner that samples may be withdrawn safely and slowly at any time during plant operation. The sampling outlet shall be installed between the pump and the return line discharge in such location that it is readily accessible. A drainage receptacle shall be provided for flushing the outlet prior to sampling.

**404.2.3 Cold Aggregate Feeder.** The plant shall be provided with an accurate mechanical means for uniformly feeding the aggregates into the drier to provide uniform production and temperature. A synchronized method of proportioning the aggregates at the cold feeder shall be provided. The gates of the fine aggregate cold feed bins shall be adjusted so that a steady, uniform stream of material is discharged.

**404.2.3.1** For all plants producing bituminous mixtures composed of more than one fraction of aggregate, the aggregate cold feeds shall be calibrated as required by the engineer. The contractor shall provide a means to readily divert the flow of material into a container for measurement. On the basis of the calibration, aggregate cold feeds shall be adjusted to ensure the proper percentage of the various aggregate fractions of the mix, as required by the job mix formula.

**404.2.3.2** For plants producing SMA mixtures, each cold aggregate feeder shall be limited to a maximum of 30 percent of the total aggregate.

**404.2.4 Drier.** A drier of any satisfactory design for drying and heating the aggregate shall be provided. The drier shall be capable of drying and heating the aggregate to a temperature within the limits of the range specified in [Sec 1015](#) for the grade of asphalt binder used, without leaving any visible unburned oil or objectionable carbon residue on the aggregate. The mixture may be tested for contamination. Feeding and drying equipment shall be operated in such a manner that the temperature of the aggregates is maintained within 25 F (15 C) above or below that specified by the engineer. Absorbed moisture in the aggregate shall be reduced to such a quantity that there is no objectionable segregation of asphalt binder resulting from escaping water vapor in the prepared mixture. A maximum of 0.5 percent moisture based on weight (mass) of the mixture, will be allowed in the mixture when sampled and tested in accordance with MoDOT Test Method T53.

**404.2.5 Dust Collector.** An efficient dust collecting system shall be provided to prevent the loss of fine material into the surrounding environment. The material collected may be returned to the mixture at a uniform rate through an approved metering device, if approved by the engineer, or it may be wasted.

**404.2.6 Screens.** Continuous mix and batch-type plants used to produce mixtures in accordance with the requirements of [Sec 403](#) shall have screens with adequate capacity and size range to separate all of the aggregate into the specified sizes required for proportioning of the mixture being produced.

**404.2.7 Bins.** Continuous mix and batch-type plants shall have hot bin storage of sufficient capacity to ensure uniform and continuous operation. Bins shall be divided into compartments arranged to ensure separate and adequate storage of appropriate fractions of the aggregate. Batch and continuous plants producing SMA mixture shall have a minimum of four separate hot bins. Each compartment shall be provided with an overflow pipe of such size and at such location as to prevent any backing up of material into other bins or into contact with the screen. The bins shall have a tailing pipe for rejections. The discharge points of overflow and tailing pipes shall be located so they will not create a hazard. Overflow pipes shall not return the material directly to the hot elevator.

**404.2.7.1** If mineral filler or hydrated lime, or both, is required, adequate dry storage shall be provided, and provision shall be made for accurate proportioning.

**404.2.7.2** Safe, adequate and convenient facilities shall be provided for obtaining representative aggregate samples from the full width and length of the discharge flow from each bin.

**404.2.8 Asphalt Control Unit.** Satisfactory means, either by weighing (by determining the mass) or metering, shall be provided to obtain the proper quantity of asphalt binder. Metering pumps for asphalt shall deliver accurately to within plus or minus 2.0 percent of the required quantity when tested for accuracy. Asphalt scales shall conform to the requirements of [Sec 404.3.5](#). If the quantity of asphalt binder is controlled by metering, provision shall be made whereby the delivery of the meter may be readily checked by actual weight (mass).

**404.2.9 Thermometric Equipment.** A thermometer of suitable range shall be fixed in the asphalt feed line at a suitable location near the discharge at the mixer unit. The thermometric device included in the asphalt metering unit shall be displayed in a location readily accessible to the engineer.

**404.2.9.1** In batch-type and continuous plants, an accurate registering pyrometer or other approved thermometric instrument shall be installed in the discharge chute of the drier in such manner that the temperature of the heated aggregate is automatically registered. Plants used to produce mixtures in accordance with the requirements of [Sec 403](#) shall be further equipped with approved recording thermometers, pyrometers or other recording thermometric instruments placed in two of the hot aggregate bins to register and record automatically the temperature of the heated aggregate. One terminal shall be placed in the hot bin containing the smallest aggregate used in the mix and the other terminal shall be placed in the bin containing the largest aggregate. The terminals shall be located where the hot material will flow around them during the proportioning operation and shall not be located near the corners of the bins or at points where the material will collect or pack around them. The charts shall continuously record both time and temperature. The smallest interval of time shown shall not be more than 15 minutes and the temperature graduations shall not be more than 10 F (5 C). The charts shall be furnished to the engineer at the end of each day's operation.

**404.2.9.2** An approved recording thermometer, pyrometer or other recording thermometric instrument shall be installed in the discharge chute of drum mix plants in such manner that the temperature of the heated mixture is automatically registered and recorded. This instrument shall be located where it is in clear view of the plant operator and readily accessible to the engineer. The chart shall continuously record both time and temperature. The smallest interval of time shown shall be not more than 15 minutes and the temperature graduations shall be not more than 10 F (5 C). The chart shall be furnished to the engineer at the end of each day's operation. The terminal shall be maintained free of accumulated mixture to ensure accuracy.

**404.2.10 Plant Calibration.** Personnel, scales and equipment necessary for calibrating the plant and for verifying the accuracy of proportions shall be furnished by the contractor and shall be available at all times. If batch-type plants are used, the equipment shall include standard 50-pound (20 kg) test weights equal to 20 percent of the net load capacity of the scales, to the nearest 50-pound (20 kg) increment. However, not more than twenty 50-pound (20 kg) weights will be required. If batch-type plants are used, calibration of the batching scales by an approved commercial scale service shall be required at the beginning of each construction season or anytime the scales do not meet calibration tolerances. If less than 1000 tons (900 Mg) of mixture is required in a construction season for a project or combination of projects, no commercial scale service shall be required unless the scales do not meet calibration tolerances. If continuous mixing or drum plants are used, scales conforming to the requirements of [Sec 310.4.3](#), shall be provided. All equipment shall be calibrated in the presence of and subject to the approval of the engineer.

**404.2.11 Safety Requirements.** A conveniently located, easily opened gate or door shall be provided in the mixer cover for observation of pugmill mixing operations. Adequate and safe stairways to the pugmill mixer platform and sampling points shall be provided. Guarded ladders to other plant units shall be placed at all points where accessibility to plant operations is required. Accessibility to the top of truck bodies shall be provided by a platform or other suitable device to enable the engineer to obtain samples and mixture temperature data. All gears, pulleys, chains, sprockets and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the pugmill mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading area. This area shall be kept free from drippings from the mixing platform.

**404.2.12 Surge Bins.** Approved surge bins may be used in the production of bituminous mixtures. They shall be equipped with batchers at the top of the surge bins, so located that the

mixture is discharged vertically from the batcher into the center of the bin. Any mixture which the engineer determines visually to be segregated will be rejected.

**404.2.12.1** Surge bins shall be covered and insulated. They shall be equipped with heating devices if necessary to maintain the temperature of the mixture in accordance with the requirements in [Sec 404.6.3](#).

**404.2.12.2** Surge bins shall be equipped with automatic lights to indicate when the surface of the mixture has been drawn down to the top of the sloped portion of the bin. The bins shall also be equipped with an automatic locking device that prevents discharging mixture when the surface of the mixture has been drawn down to the top of the sloped portion of the bin. The automatic locking device may be unlocked by the engineer to terminate operations for the day or to dispose of the mixture off the highway right of way.

**404.2.12.3** Mixture shall be transferred from the mixing plant to the surge bins by covered drag slat conveyors, skip hoists or other methods approved by the engineer. Mixture shall not be stored more than 8 hours.

**404.2.12.4** Storage of SMA mixture shall be limited to the intermittent holding of the mix in the surge hopper while loading of trucks is performed, due to the tendency of the asphalt binder in SMA to drain from the mix.

**404.2.13 Automatic Ticket Printer.** For contracts having more than 10,000 tons (9000 Mg) of bituminous mixture, the asphalt plant shall be equipped with an automatic ticket printer connected to the weighing (mass determination) system in such manner that it automatically detects and prints the weight (mass) determined by the system. It shall store and recall the tare weight (mass) when the operator enters the vehicle identification. The weight (mass) shall be shown to at least the nearest 20 pounds (10 kg) or nearest one one-hundredth of a ton (megagram). The automatic printer shall be capable of keeping and printing cumulative totals for each project for each type of bituminous mixture. The automatic printer shall produce a ticket showing the weight (mass) for each load in triplicate that shows the following:

- (a) Gross, tare and net weights (masses).
- (b) Identification of the vehicle.
- (c) Current date and time.
- (d) MoDOT job mix number.
- (e) Job mix percent asphalt binder.
- (f) Unique ticket number (may be preprinted on the ticket).
- (g) Project number, job number, route, county.

The ticket shall accompany each load delivered to the project and shall be furnished to the engineer.

**404.2.13.1** When the net weight (mass) of bituminous mixture is determined by batch weights (masses), the scales shall meet all requirements of [Sec 404.2.13](#) including automatic ticket printing, except the gross and tare weights (masses) will not be required.

**404.2.13.2** When the net weight (mass) of bituminous mixture is determined from the gross weight (mass) of the loaded delivery vehicle, the net weight (mass) shall be determined from the gross weight (mass) of the loaded delivery vehicle less the empty delivery vehicle weight (mass). The empty delivery vehicle weight (mass) shall be determined daily or from time to time during the day as the engineer may direct.

**404.2.13.3** At the end of each day's operation the contractor shall furnish to the engineer a total tonnage (quantity) of mixture produced by the asphalt plant in sufficient detail to determine the amount of asphalt binder used in that day's operation.

**404.2.13.4** In the event of automatic ticket printer failure, the contractor may be allowed, with the engineer's approval, to furnish manually written tickets to complete that day's operation.

#### **404.3 Requirements for Batch-Type Plants.**

**404.3.1** For all contracts having not more than 10,000 tons (9000 Mg) of bituminous mixture, standard manual batching methods, approved by the engineer, will be permitted. For contracts having more than 10,000 tons (9000 Mg) of bituminous mixture, required by [Sec 301, 401 or 403](#), batching plants shall be equipped to operate automatically to the extent that the only manual operation required for the proportioning of all ingredients for one batch shall be a single actuation of a switch or starter. The equipment shall include devices capable of automatically proportioning each ingredient of the mixture in the selected sequence and quantity. Interlocks shall be provided which will hold or delay the automatic batch cycling whenever the batched quantity of any ingredient is not within the specified tolerance. The weight (mass) setting and timing controls shall be suitably equipped so they may be locked when specified by the engineer. Manual operation will not be permitted beyond 24 hours after breakdown in the automatic equipment, except by written approval of the engineer.

**404.3.2 Weigh Box or Hopper.** The equipment shall include a means for accurately weighing (determining the mass of) aggregate from each bin into a weigh box or hopper, suspended on scales, and ample in size to hold a full batch without hand raking or running over. Weigh boxes shall be charged through only one gate opening for aggregate from each bin. The weigh box or hopper shall be supported on fulcrums and knife edges so constructed that they will not easily be thrown out of alignment or adjustment. Gates on the bins and the hopper shall be constructed to prevent leakage when they are closed.

**404.3.3 Aggregate Scales.** Scales for weighing (determining the mass of) aggregate and mineral filler or hydrated lime, or both, may be beam, springless dial or electronic digital weigh (mass determination) meter type, and shall be of standard make and design having tolerances on overregistration and underregistration not exceeding 0.4 percent of the indicated weight (mass) when tested for accuracy. Each aggregate fraction shall be measured within one percent of the total batch weight (mass) of the mixture. Mineral filler or hydrated lime, or both, shall be measured within 0.5 percent of the total batch weight (mass) of the mixture. The total weight (mass) of the batch shall be within 2.0 percent of the desired batch weight (mass). The change in load required to change the position of the rest of the indicating element or elements of a non-automatic indicating scale an observable amount shall not be greater than 0.1 percent of the nominal scale capacity. If manual batching methods are used, beam-type scales shall be equipped with a device to indicate to the operator that the required load is being approached. This device shall indicate at least the last 5 percent of the load weighed (determined) on any beam, except that this increment will not be required to be greater than 200 pounds (100 kg). Multiple beam-type scales shall be equipped with a tare beam and a separate beam for each size of aggregate. Dial scales shall be equipped with adjustable pointers for marking the weight (mass) of each material to be weighed (incorporated) into the batch. Graduation intervals for either beam or dial scales shall not be

greater than 0.1 percent of the nominal scale capacity. Quantity indicators necessary for batching shall be in full view of the operator.

**404.3.3.1** Automatic volumetric batch proportioning approved by the engineer will be permitted and shall meet the tolerances specified in [Sec 404.3.3](#).

**404.3.4 Asphalt Bucket.** If a bucket is used for weighing (determining the mass of) the asphalt binder, it shall be of sufficient capacity to hold and weigh (determine the mass of) the quantity required for a batch in a single weighing (mass determination). The filling system and bucket shall be of such design, size and shape that asphalt will not overflow, splash or spill outside the confines of the bucket during filling and weighing (mass determination). The bucket shall be steam or oil-jacketed or equipped with properly insulated electric heating units.

**404.3.5 Asphalt Scales.** Scales for weighing (determining the mass of the) asphalt binder shall conform to the requirements for aggregate scales, as specified in [Sec 403.3.3](#), except a device to indicate at least the last 20 pounds (10 kg) of the approaching total load shall be provided. Asphalt binder shall be measured within 0.1 percent of the total batch weight (mass) of the mixture. Beam-type scales shall be equipped with a tare beam or adequate counter-balance for balancing the bucket and compensating periodically for the accumulation of asphalt on the bucket. Springless dial scales used for weighing (determining the mass of) asphalt binder shall have a tare beam, and a dial graduated in increments not to exceed 0.1 percent of the nominal scale capacity, and the maximum dial capacity shall not be more than 15 percent of the nominal capacity of the mixer.

**404.3.6 Mixer Unit.** The plant shall include an approved twin shaft pugmill mixer capable of producing a uniform mixture. The mixer shall be electrically heated or hot oil or steam jacketed and have a capacity of not less than 2000 pounds (900 kg) per batch. The mixer shall be constructed to prevent leakage of the contents, and the mixer box shall be equipped with a hood to prevent loss of dust.

**404.3.6.1** The mixer shall be designed to provide means of adjusting the clearance between the mixer blades and liner plates to ensure proper and efficient mixing. Not more than one pair of paddle tips on each mixer shaft shall be reversed with respect to the other paddle tips on that shaft, except for mixers having forty paddles or more, then two pair may be reversed on each shaft. The reversed paddle tips shall be located in diagonally opposite corners of the pugmill. The clearance of blades from all fixed and moving parts shall not exceed 3/4 inch (19.0 mm).

**404.3.6.2** The mixer shall have an accurate time lock to control the operation of a complete mixing cycle by locking the weigh box gate after the charging of the mixer until the closing of the mixer gates at the completion of the cycle. The time lock shall lock the asphalt bucket throughout the dry mixing period and shall lock the mixer gate throughout the dry and wet mixing periods.

**404.3.6.3** A rating plate designating the manufacturer's rated capacity shall be attached to the mixer. The quantity of mixture produced per batch shall not exceed the manufacturer's rated capacity. The manufacturer's rated capacity will not be accepted unconditionally. If the mixer does not produce a satisfactory mixture or its production does not coordinate with other plant units, the right is reserved to reduce the size of the batch. The decision of the engineer as to the permissible capacity of the mixer shall be final.

#### **404.4 Requirements for Continuous Mixing Plants.**

**404.4.1 Gradation Control Unit.** The plant shall include a means of accurately checking the proportioning from each bin by weight (mass). Means shall be provided to establish the rate of flow in pounds (kilograms) per revolution by scale weight (mass). On each of the storage bins for the heated aggregates, a device shall be installed to indicate when the level of the material in the bin is below the point where accurate proportioning through the feeder gates can be accomplished. These indicators shall be positive in action and shall actuate a clearly visible or audible signal to the plant operator or stop the flow of material to the mixer when the material in the bin is too low for accurate proportioning.

**404.4.1.1** The gradation control unit shall include interlocked feeders mounted under the bin compartments. The interlocked feeders shall be equipped with a dustproof revolution counter registering to the nearest 0.01 revolution. The mix proportions shall be set up on the basis of pounds (kilograms) of aggregate from each bin per revolution. Each bin shall have an accurately controlled, individual gate to form an orifice to control the rate of flow of aggregate drawn from each respective bin compartment. The orifice shall be rectangular with one dimension adjustable by positive mechanical means. Locks shall be provided on each gate. Calibrated gauges with minimum graduations of not more than 0.1 inch (2 mm) shall be provided for each gate to establish gate openings. The rate of flow of the aggregate through the gate openings shall verify within 5 percent of the quantity as calibrated for that opening, or within 2 pounds (1 kg) per revolution of the aggregate feeder, whichever is the greater. The rate of flow shall also verify within a total variation of not more than 2 percent of the total quantity required of the combined bins, exclusive of mineral filler and hydrated lime, or one pound (0.5 kg) per revolution for each gate through which aggregate is being proportioned, whichever is the greater.

**404.4.1.2** If mineral filler or hydrated lime, or both, is specified, a separate bin and feeder for each of these material shall be furnished with its drive interlocked with the aggregate feeders. Readily accessible ports or openings for observation of the flow of mineral filler or hydrated lime, or both, through the conveyor or delivery system shall be provided. The rate of flow of the mineral filler or hydrated lime feeder shall be accurate to within 0.5 percent of the rate of flow of the total mix, or to 1/2 pound (0.25 kg) per revolution of the aggregate feeder, whichever is the greater.

**404.4.2** If a continuous mixing plant is used, a continuously registering measurement meter and a pressure gauge shall be installed in the asphalt line at locations meeting the approval of the engineer. The meter shall be cumulative with a nonsetback register, and have an accuracy within 2 percent by weight (mass) of the material actually being measured in any given period of time. The meter register shall indicate the quantity measured to the nearest 0.25 gallon (one liter) or less. The pressure gauge shall have a range capable of registering all spraying pressures during plant operation and the dial shall have increments of not more than one pound per square inch (10 kPa). The meter and the pressure gauge shall be so located in the asphalt line that the meter will continuously register the asphalt discharge and the gauge will continuously register the discharge or spraying pressure, and also so that the discharge through both the meter and the gauge can be readily diverted to a container for measurement. During calibration and verification of the asphalt metering pump and the measurement meter, the discharge pressure shall be controlled by a valve or reduction unit to duplicate the plant's spraying pressure. The accuracy of the measurement meter shall be verified at periodic intervals as specified by the engineer. In case of meter malfunction, plant operation will not be permitted beyond 24 hours after detection except by written approval of the engineer.

**404.4.3 Weight (Mass) Calibration of Asphalt and Aggregate Feed.** The plant shall include a means of calibrating gate openings and asphalt flow by means of weighed (mass determination of) test samples in pounds (kilograms) per revolution. The aggregate fed out of the bins through individual orifices shall be bypassed into suitable test boxes and each

compartment material shall be confined in individual test receptacles or compartments. Accessories shall be supplied so that the aggregate weight (mass) in each compartment may be determined separately. Test containers shall be of a size to obtain a minimum weight of 200 pounds (minimum mass of 90 kg), or the quantity from not less than five complete revolutions, whichever is the smaller, for each test-run made from each bin. In any case, the quantity from not less than one complete revolution will be required.

**404.4.4 Synchronization of Aggregate and Asphalt Feed.** Satisfactory means shall be provided to afford positive interlocking between the flow of aggregate through the gates, the flow of mineral filler or hydrated lime through each feeder, and the flow of asphalt binder through the meter or other proportioning source. Means shall be provided to check the rate of flow of the asphalt binder by scale weight (mass) per revolution. The pump shall deliver the asphalt to the pugmill at a uniform rate which shall not vary more than 2.0 percent by weight (mass) from the required quantity.

**404.4.5 Mixer Unit.** The plant shall be equipped with a twinshaft, electrically heated or hot oil or steam jacketed pugmill, capable of producing a uniform mixture within the permissible job-mix tolerances. It shall have a capacity of not less than 40 tons (35 Mg) per hour. The paddles shall be of a type adjustable for angular position on the shafts and reversible to retard the flow of the mix. The clearance of blades from all fixed and moving parts shall not exceed 3/4 inch (19.0 mm). Mixers shall be equipped with discharge hoppers or other facilities to prevent segregation during discharge.

**404.4.5.1** The mixer shall carry a manufacturer's plate giving the net volumetric content of the mixer at the several heights inscribed on a permanent gauge. The manufacturer's rating of the mixing unit will not be accepted unconditionally. The right is reserved to reduce the rate of feed of aggregate at plant-operating speed to produce a satisfactory mixture. The decision of the engineer as to the permissible capacity of the mixing unit shall be final.

**404.4.5.2** The mixing time shall be determined as follows:

$$\begin{array}{lcl} \text{Mixing time} & = & \frac{\text{Pugmill dead capacity in pounds (kilograms)}}{\text{Pugmill output in pounds (kilograms) per second}} \\ \text{in seconds} & & \end{array}$$

#### **404.5 Requirements for Drum Mix Plants.**

**404.5.1** The plant shall be specifically designed for drum mixing and be capable of satisfactorily heating, drying and mixing the bituminous mixtures. The system shall be equipped with automatic burner controls, and heating shall be controlled to prevent damage to the aggregate or the asphalt binder. The temperature of the mixture when discharged from the mixer shall be within the range specified in [Sec 1015](#) for the grade of asphalt binder being used. The rate of flow through the drum shall be controlled in order that the bituminous material and aggregate shall be mixed until a homogeneous mixture with all particles uniformly coated is obtained and in no case shall the quantity of mixture produced exceed the manufacturer's rated capacity.

**404.5.2** Each feeding orifice shall have an adjustable gate with an indicator provided to reference the opening setting. On each of the aggregate feeders, a device shall be installed to indicate when the flow of material from the bin is below the point where accurate proportioning through the feeder gates can be accomplished. These indicators shall be positive in action and shall actuate a clearly visible or audible signal to the plant operator or stop the flow of material to the drum when the level of material in the bin is too low for accurate proportioning. In addition, for those particular cold bins whose aggregate material tends to either bridge or lump together causing temporary interruptions in feeds, a vibrator or



other suitable means shall be provided to ensure uniform flow. The order of aggregate feed onto the composite cold feed belt shall be from coarse to fine. When only one aggregate is furnished, two cold bins shall be used. A scalping screen mounted independent of other proportioning or weighing (mass determination) equipment shall be required if directed by the engineer.

**404.5.3** Asphalt binder shall be introduced through a continuously registering cumulative indicating meter by a pump specifically designed for drum mix plants. The meter shall be located in the asphalt line so that it will continuously register the asphalt discharge to the mixer and so that the discharge through the meter can be readily diverted into a container for measurement. The meter shall be equipped with a nonsetback register and shall have an accuracy within 2 percent by weight (mass) of the material actually being measured in any given period of time. The nonsetback register shall register only the asphalt discharged to the mixer and shall not record asphalt circulated back to the storage tank. A device shall be provided in the asphalt storage tank to indicate when the supply of asphalt to the pump and metering device is such that accurate proportioning is not accomplished. The accuracy of the pump and meter shall be verified at periodic intervals as designated by the engineer.

**404.5.4** If mineral filler or hydrated lime, or both, is specified, a separate bin and feeder for each material shall be furnished and each material shall be dispensed by weight (mass) by continuous batching device. The batching device shall have a continuous weight (mass) display in clear view of the plant operator. The delivery system shall be variable speed and interlocked with the aggregate weigh belt so the total dry aggregate weight (mass), including mineral filler or hydrated lime, or both, is indicated to the asphalt proportioning system. A continuously registering, cumulative, nonsetback register shall record the quantity of mineral filler or hydrated lime, or both, discharged into the mixer. Mineral filler and hydrated lime shall be introduced and uniformly dispersed into the drum mixer at the point of introduction of the asphalt binder without loss to the dust collection system. The mineral filler and hydrated lime proportioning and delivery system shall have an accuracy of 10 percent by weight (mass) of the material actually being measured in any given period of time.

**404.5.5** Positive weight (mass) measurement of the combined cold feed aggregates shall be by use of belt scales. The combined cold aggregate feed shall be continuously recorded on a nonsetback register. The belt scale shall have an accuracy within 2 percent by weight (mass) of the material actually being measured in any given period of time. The accuracy of the belt scales shall be verified at periodic intervals as directed by the engineer. Means shall be provided to readily divert the flow of cold feed aggregates into a container for measurement. The scale and the conveyor at the scale shall be protected from wind and weather effects. The plant shall be equipped so that the proportion of each aggregate can be individually varied. The plant shall also be equipped so that the total aggregate rate can be varied without affecting the proportions of each individual aggregate.

**404.5.6** Positive weight (mass) measurement of reclaimed asphaltic pavement shall be by use of belt scales complying with the requirements of [Sec 404.5.5](#).

**404.5.7** The aggregate feed system, reclaimed asphaltic pavement feed system if recycling is permitted, mineral filler or hydrated lime, or both if specified, and the asphalt flow shall be interlocked by a blending system which will automatically regulate the asphalt binder, mineral filler, hydrated lime and reclaimed asphaltic pavement flow and cause synchronized corrections for variations in aggregate flow. The blending system shall include a moisture compensating device to correct for the moisture in the aggregates passing over the belt scales. Moisture determinations will be made periodically during each day's operation. The blending system shall also include a device to correct for changes in the specific gravity of the asphalt binder.

**404.5.8** Safe, adequate and convenient facilities shall be provided for obtaining representative samples of asphalt binder, cold aggregate and bituminous mixture. The plant shall be equipped with sampling devices capable of providing a sample of sufficient size from the full width of the combined aggregate flow and from the full width of the mixer discharge flow. Sampling devices shall be designed so that samples may be taken while the plant is operating at normal production rates.

**404.5.9** Safe, adequate and convenient facilities shall be provided for calibrating or verifying the asphalt binder, mineral filler, hydrated lime, reclaimed asphaltic pavement and the aggregate nonsetback registers. The manufacturer's recommendations shall be followed for calibration when not in conflict with these specifications. To calibrate or verify the aggregate, mineral filler, hydrated lime or reclaimed asphaltic pavement nonsetback register, means shall be provided to permit a positive and uniform diversion of the material in sufficient quantity for accurate weight (mass) checks. To calibrate or verify the asphalt nonsetback register, an asphalt distributor or other equipment approved by the engineer shall be made available so that an accurate tare, gross and net weight (mass) may be obtained of the diverted asphalt discharge. If necessary, manual overrides of the equipment shall be provided for calibration or verification purposes. The quantities of aggregate and asphalt binder measured in any given period of time shall not vary by more than 2.0 percent by weight (mass) from the required quantity of each.

**404.5.10** A surge bin in accordance with [Sec 404.2.12](#) will be required unless otherwise authorized by the engineer.

#### **404.6 Preparation of Asphalt Binder, Aggregates and Mixtures.**

**404.6.1 Drum Mix Plants.** Preparation of asphalt binder, aggregates and mixtures shall be in accordance with the applicable requirements of [Sec 404.5](#).

##### **404.6.2 Batch-Type and Continuous Mixing Plants.**

**404.6.2.1 Preparation of Asphalt Binder.** Asphalt binder shall be heated in either steam, electric or oil heated tanks or kettles and shall be maintained during the period that mixture is manufactured, at a temperature within the limits of the range specified in [Sec 1015](#). If asphalt binder is measured by volume, the temperature of the asphalt binder at the time of measuring shall not vary more than 15 F (8 C) from that specified by the engineer when the metering device was calibrated. The equipment for handling the asphalt, including pumps, pipe lines and storage tanks, shall be entirely separate and have no connections to the system used for handling fuel oil or other material on the project.

**404.6.2.2 Preparation of Aggregate.** The mineral aggregate shall be fed into the drier through approved aggregate feeders which will accurately control the total and proportional feed. Each fraction shall be proportioned through a separate mechanical feeder. If the aggregate is furnished in one fraction, a minimum of two cold aggregate feeders will be required. The temperature of the aggregate, when delivered to the mixer, shall be within the range specified in [Sec 1015](#), for the grade of asphalt binder being used.

##### **404.6.2.3 Preparation of Mixture.**

**404.6.2.3.1** Aggregate from each hot bin, mineral filler or hydrated lime, if specified, and asphalt binder shall be accurately proportioned in the quantities required by the job-mix formula.

**404.6.2.3.2 Batch-Type Plants.** Aggregate shall be charged into the weigh hopper in a sequence that will avoid segregation. The mineral aggregate for mixtures specified in [Sec 301](#), [401](#), and [402](#) shall be mixed dry for not less than 10 seconds, and for mixtures specified in [Sec 403](#) shall be mixed dry for not less than 15 seconds. The dry mixing period for Type I-B mixtures may be decreased to not less than 10 seconds, provided there is no segregation of the aggregates. The dry mixing period shall start when all of the mineral aggregates have been charged into the mixer and end when the introduction of the asphalt binder begins. After dry mixing, the asphalt binder shall be charged into the mixer in a manner that will uniformly distribute the asphalt over at least 3/4 of the full length of the mixer. The time required to add the asphalt binder shall not exceed 15 seconds. Wet mixing shall begin at the introduction of the asphalt binder and continue for at least 30 seconds, or longer if necessary to produce a complete and uniform coating of the particles and a thorough distribution of the asphalt binder throughout the aggregate. The wet mixing period shall end when the discharge gate is opened. The dry and wet mixing times shall be as specified by the engineer.

**404.6.2.3.3 Continuous Mixing Plants.** The mixing period shall be determined in accordance with [Sec 404.4.5.2](#) and shall be not less than 35 seconds. The mixing time shall be as specified by the engineer, and may be increased above the minimum specified if necessary to produce a complete and uniform coating of the particles and a thorough distribution of the asphalt binder throughout the aggregate.

**404.6.3 Final Mixture.** The final mixture, when discharged from the pugmill or drum, shall not vary more than 25 F (15 C) from 300 F (150 C) unless otherwise specified by the engineer, and in all cases shall be within the same range as that specified in [Sec 1015](#) for the grade of asphalt binder being used.

**404.6.4 SMA Mixtures.** A homogeneous mixture shall be produced.

**404.6.4.1** For batch plants, fibers shall be added to the mineral aggregates either in the weigh hopper or in the pugmill. The fibers shall be accurately added by weight (mass), either manually by bag or other measure, or by an approved weight (mass) metering device. If fibers are added in the weigh hopper, no fibers shall be added until mineral aggregate from at least one hot bin has been placed in the weigh hopper. If fibers are added in the pugmill, the fibers shall be added immediately after the mineral aggregates and before the asphalt binder is added.

**404.6.4.1.1** The mineral aggregates and the fibers shall be dry mixed for at least 20 seconds and a maximum of 35 seconds.

**404.6.4.1.2** The wet mixing time shall not be less than 35 seconds to allow the cellulose fibers to expand and ensure adequate distribution of the fibers and asphalt binder.

**404.6.4.1.3** Dry and wet mixing times and batch mixing temperatures may be otherwise adjusted as necessary by the engineer.

**404.6.4.2** For drum and continuous mix plants, fibers shall be introduced into the plant in either loose or pelletized form.

**404.6.4.2.1** Metering fibers into the plant requires specialized equipment to ensure a consistent, uniform blending of the fibers into the mixture and shall be accomplished as specified by the manufacturer of the equipment to the satisfaction of the engineer. The metering system shall be variable speed and shall proportion the fibers by weight (mass).

**404.6.4.2.2** If used in a drum mix plant, pelletized fiber shall be added directly into the drum mixer through the recycle asphalt inlet.

**404.7 Hauling Equipment.** Trucks used for hauling bituminous mixtures shall have tight, clean, smooth, metal beds which have been thinly coated with a minimum quantity of lime solution or an approved bituminous mixture release agent meeting the requirements of [Sec 1071](#) to prevent the mixture from adhering to the beds. Use of diesel fuel, fuel oil or other detrimental products as a bed coating will not be allowed. The release agent shall not be diluted less than the minimum rate specified by the manufacturer and shall be applied with equipment as recommended by the manufacturer. Dilution shall not be by diesel fuel or other petroleum products.

**404.7.1** Each truck shall have a cover of canvas or other suitable material of such size as to protect the mixture from the weather. The cover shall be securely fastened over all sides of the truck bed. When necessary, so that the mixture will be delivered on the road at the specified temperature, truck beds shall be insulated. No loads shall be sent out so late in the day that spreading and compacting of the mixture cannot be completed during daylight, unless there is adequate lighting in the area of work.

## SECTION 405

### ROAD MIX BITUMINOUS PAVEMENT

**405.1 Description.** This work shall consist of constructing one or more courses of road mix bituminous pavement on a prepared base or road surface in accordance with these specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer. Approved plant mix methods may also be used.

**405.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Graded Aggregate for Bituminous Surface	1004
Type MC Liquid Asphalt	1015

The grade of liquid asphalt and the grade of aggregate will be specified in the contract. The liquid asphalt may be changed one grade by the engineer during construction at no change in unit price. The liquid asphalt and mineral aggregate shall result in a mixture which will be durable and retain satisfactory cohesion and stability in the presence of moisture. Chemical additions, approved by the engineer, may be made to the liquid asphalt or to the mixture.

**405.2.1 Commercial Mixture.** The use of a commercial mixture will be considered by the engineer on contracts requiring not more than 700 cubic yards (550 m<sup>3</sup>) or 1000 tons (1000 Mg) of aggregate for road mix bituminous pavement. The contractor shall, at least seven days prior to the desired time of use, furnish a statement setting out the source and characteristics of the mixture the contractor proposes to furnish. The statement shall include (1) the types and sources of aggregates, percentage of each and combined gradation, (2) the percent and grade of asphalt, and (3) the mixing time and range of mixture temperature. The plant shall be designed and operated to produce a uniform, thoroughly mixed material free from segregation. If the proposed mixture and plant are approved by the engineer, the component material and the mixture delivered will be accepted or rejected by visual inspection. The supplier shall furnish a certification in triplicate that the material and mixture are in conformance with the contractor's approved proposal. The material shall be placed and compacted in accordance with the requirements specified herein.

**405.3 Equipment.** The equipment used by the contractor shall include scarifying, mixing, spreading, finishing and compacting equipment, a bituminous distributor and equipment for heating liquid asphalt.

**405.3.1 Heating.** Equipment for heating liquid asphalt in tanks, railroad cars, trucks and distributors shall meet the approval of the engineer and shall be capable of heating the material to the required temperature without the introduction of moisture, localized overheating or otherwise changing the characteristics of the material.

**405.3.2 Distributor.** The distributor shall be so designed, equipped, maintained and operated that liquid asphalt at even heat may be applied uniformly on variable widths of surface up to 15 feet (4.5 m) at readily determined and controlled rates from 0.02 to 1.00 gallon per square yard (0.1 to 4.6 L/m<sup>2</sup>), with uniform pressure, and with an allowable variation from any specified rate not to exceed 0.02 gallon per square yard (0.1 L/m<sup>2</sup>). Distributor equipment shall include a tachometer, pressure gauges, a calibrated tank and a thermometer for

measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump, and full circulation spray bars adjustable laterally and vertically. The calibration of all distributors must be approved by the engineer, and the contractor shall furnish all equipment, material and assistance necessary if calibration is required.

**405.3.3 Miscellaneous Equipment.** Equipment which will break, rut, score or distort the surface to remain in place, or being placed, as well as blade graders which cause corrugations will not be permitted. A power driven sweeper and a windrow evener which will provide a uniform windrow of proper size will be required. Other approved equipment shall be used as required for mixing.

**405.3.4 Rollers.** Approved pneumatic tire rollers weighing (having a mass of) not less than 10 tons (9 Mg) may be used; however, final rolling shall be done by a self-propelled steel wheel roller weighing (having a mass of) not less than 10 tons (9 Mg). The roller wheels shall be equipped with scrapers and a system for moistening each wheel or roll to prevent sticking of bituminous material.

**405.3.5 Mixing Plants.** Traveling or stationary mixing plants having a capacity of not less than 300 cubic yards (200 m<sup>3</sup>) of mixed material per 8-hour day, or other equipment of proven performance may be used by the contractor in lieu of the specified equipment if approved. Plant equipment shall include a thermometer indicating the temperature of the liquid asphalt at the time of mixing and any necessary instruments for determining the quantity of liquid asphalt entering the mix at any given time. Both the aggregate and asphalt feed controls shall be within easy reach of the operator controlling mixing.

#### **405.4 Construction Requirements.**

**405.4.1 Weather Limitations.** Bituminous mixtures shall not be placed (1) when either the air temperature or the temperature of the surface on which the mixture is to be placed is below 40 F (5 C), (2) on any wet or frozen surface, or (3) when weather conditions prevent the proper handling or finishing of the mixture. Temperatures are to be obtained in accordance with MoDOT Test Method T20.

**405.4.2 Preparation and Maintenance of Base.** If a prime coat is required, it shall be left undisturbed not less than 24 hours following application. The contractor shall maintain the primed surface until the road mix bituminous pavement has been placed. This maintenance shall include the patching of any breaks in the primed surface with additional bituminous material. If a tack coat is required, it shall be applied only as far in advance of the placing of the mixture as is necessary to obtain the proper condition of tackiness. Any breaks in the tack coat shall be repaired. Maintenance of base shall be at the contractor's expense.

**405.4.3 Placing Aggregates.** Aggregates shall be deposited on the roadbed and bladed into a uniform windrow on one shoulder on tangents, and on the high shoulder of curves throughout the project, at the rate specified in the contract or as directed by the engineer.

**405.4.3.1** Immediately before the application of asphalt, the windrow shall be placed adjacent to and on one side of the centerline and all loose material swept into the windrow by using a power driven sweeper and evened to the required size by the use of a windrow evener. If it becomes necessary to spread a properly evened windrow of aggregate for drying, it shall be windrowed, and evened if required, before application of the asphalt.

**405.4.3.2** If mixing is to be done with a traveling plant, the following method may be used in lieu of the evening operation. The first 1000 linear feet (300 m) shall be evened as outlined above and the aggregate feed of the machine shall be calibrated. On the remainder of the

project, the evening operation may be superficial, with the aggregate feed control being permitted to serve in lieu of evening. If this method is used, the aggregate feed control shall not be varied by more than 5 percent after it has been calibrated and set by the engineer. The contractor shall keep sufficient aggregate in the windrow to supply the aggregate feed, and shall haul material into the windrow or haul excess ahead when necessary.

**405.4.4 Application of Liquid Asphalt.** No asphalt shall be applied to or mixed with the aggregate until the aggregate has been surface dried. To receive each application of asphalt, the properly evened and dried windrow shall be spread to about a 12-foot (3.5 m) width. Liquid asphalt shall be heated at the time of application to a temperature specified by the engineer in accordance with the limits provided in [Sec 1015](#). The asphalt shall be applied by a distributor with a spray bar approximately 10 feet (3 m) long. The application shall be made in not less than two increments, the first of which shall not exceed one half the total quantity required. Between these several treatments the material shall be mixed, windrowed and respread at least once. Suitable mixing equipment shall follow immediately behind the distributor giving the mixture a preliminary manipulation.

**405.4.5 Mixing.** After the last application of asphalt, and following partial mixing, the entire amount (mass) of asphalt and aggregate shall be windrowed on the road surface and then mixed, by blading the mixture from side to side of the road, or by manipulations producing equivalent results, until the mixture is homogeneous and uniform in color. During the mixing operations, care shall be taken to avoid cutting into the underlying course or contaminating the mixture with earth or other extraneous matter. When directed, the mixing process shall be confined to part of the width or area of the road to allow traffic to pass. The material shall be mixed in sections not less than 1/2 mile (1 km) long unless otherwise permitted by the engineer.

**405.4.5.1** If, in the judgment of the engineer, the mixture does not contain the proper quantity of asphalt after mixing, more asphalt or aggregate shall be added and mixing continued until a satisfactory mixture is attained. If the addition of asphalt or aggregate and subsequent mixing are the result of a change in the engineer's directions, such additional manipulation will be paid for as change in the work in accordance with [Sec 104.3](#).

**405.4.5.2** If an approved traveling mixing plant is used, the asphalt shall be added during the mixing operation in the quantity specified by the engineer. Additional manipulation may be required. If, in the judgment of the engineer, the mixing in the traveling plant is satisfactorily performed and the mixed windrow does not contain the proper quantity of asphalt, more asphalt or aggregate shall be added according to his directions, and the windrow shall be mixed until a satisfactory mixture is attained. If the addition of asphalt or aggregate and subsequent mixing are the result of a change in the engineer's directions, the additional manipulation will be paid for as change in the work in accordance with [Sec 104.3](#).

**405.4.5.3** After the aggregate and asphalt have been mixed as required, they shall be windrowed on one side of, and adjacent to the centerline of the road. If the windrow is not uniform in size, it shall be made so by shifting a portion of the material. All material to which asphalt has been applied shall be mixed and windrowed the same day the asphalt is added. Should rain occur during the mixing, the mixture shall be windrowed immediately and shall not be disturbed until the roadbed and outer layer of the windrow are dry.

**405.4.6 Spreading, Compacting and Finishing.** Laying a tack coat of the same grade of asphalt as the binder may be required by the engineer after mixing is completed. The width of the completed tack coat shall be the width specified for the finished surface course and shall be applied to only one half the width of the base at a time. As the tack coat is applied, the windrow of asphalt-aggregate mixture shall be split and one half of it shall be spread over the

tack coat by a self-propelled, pneumatic tire blade grader or a mechanical spreader of approved type. In spreading from the windrow, care shall be taken to avoid cutting into the underlying base.

**405.4.6.1** The other one half of the windrow shall be bladed across the centerline to permit the tack coat to be applied to the opposite one half of the base, after which the remaining mixture shall be spread over the tack coat. The spreading of the material over the tack coat shall be done so that a small windrow will be formed, the outer edge of which coincides with the edge of the finished surface. Final spreading and shaping shall proceed with the small windrows being bladed and spread from the edges toward the center in such manner that the finished surface will be smooth and of uniform texture. Care shall be taken to smooth out the junction of successive spreads. The contractor shall adjust the surface of the base at bridge ends so that the new surface will have a uniform grade connection and a smooth riding surface.

**405.4.6.2** All mixed material shall be spread within 24 hours after it is mixed, unless the tack has not cured, the base is wet or the mixed material contains an excess of moisture. No mixture shall be spread after dark. If the material becomes wet after spreading but before being rolled, the material shall be thoroughly dried and relaid as soon as weather permits.

**405.4.6.3** Immediately after the material has been spread to a uniform across section, the surface shall be rolled longitudinally at a speed not in excess of 3 miles per hour (5 km/h). Rolling shall start at the edges and shall progress toward the center, overlapping on successive trips by not less than 6 inches (150 mm). The mixture shall be thoroughly compacted by not less than three complete coverages over the entire area with the final passes of the roller being made along the edges of the pavement.

**405.4.6.4** Prior to acceptance, the contractor shall maintain the bituminous surface, smoothing out all ruts and irregularities, patching any raveled areas and correcting any other defects, as directed by the engineer. If, after spreading and at any time before acceptance, there are any sections which require more bituminous material, the contractor shall distribute a light application on those sections as directed, payment for which shall be fully covered by the contract unit price for liquid asphalt.

#### **405.5 Method of Measurement.**

**405.5.1** Measurement of liquid asphalt, to the nearest 10 gallons (50 L), will be made as specified in [Sec 1015](#).

**405.5.2** Measurement of aggregate will be made in accordance with the applicable requirements of [Sec 310.4](#).

**405.5.3** Measurement of processing will be made to the nearest 0.01 mile (0.1 km) along the centerline of the pavement, or each pavement of a divided highway, regardless of the width of the completed surface.

**405.5.4** If specified in the contract as a complete product in place, road mix bituminous pavement will be measured to the nearest square yard (square meter).

**405.5.5** If the contractor elects to substitute a commercial mixture in accordance with [Sec 405.2.1](#), payment will be based on contract quantities unless an authorized revision has been made in the area to be surfaced.

**405.6 Basis of Payment.** The accepted quantities of road mix bituminous pavement will be paid for at the unit price for each of the pay items included in the contract.



## SECTION 407

### TACK COAT

**407.1 Description.** This work shall consist of preparing and treating an existing bituminous or concrete surface with bituminous material, and blotter material if required, in accordance with these specifications and in conformity with the lines shown on the plans or established by the engineer.

**407.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Emulsified Asphalt (SS-1, SS-1H, CSS-1 or CSS-1H)	<a href="#">1015</a>

**407.2.1** Aggregate used for sanding tack shall be a fine, granular material naturally produced by the disintegration of rock of a siliceous nature, or fines manufactured from igneous rock, chert gravel or flint sand.

**407.3 Equipment.** The contractor shall provide equipment for heating and applying the bituminous material and for applying blotter material. This equipment shall meet the requirements of [Sec 405](#).

#### **407.4 Construction Requirements.**

**407.4.1 Weather Limitations.** Tack coat shall not be applied when either the air temperature or the temperature of the surface to be tacked is below 40 F (5 C). Temperatures are to be obtained in accordance with MoDOT Test Method T20.

**407.4.2 Preparation of Surface.** The existing surface shall be free of all dust, loose material, grease or other foreign material at the time the tack is applied. Any fat bituminous surface mixture or bituminous joint material will be removed by others without cost to the contractor before the tack is applied.

**407.4.3 Application.** Asphalt emulsion shall be applied uniformly with a pressure distributor at the rate specified in the contract, or as revised by the engineer to be within a minimum of 0.02 (0.1) and a maximum of 0.10 gallon per square yard (0.45 L/m<sup>2</sup>). Water may be added to the asphalt emulsion and mixed therewith in such proportion that the resulting mixture will contain not more than 50 percent of added water, the exact quantity of added water to be specified by the engineer. The application of the resulting mixture shall be such that the original emulsion will be spread at the specified rate. The asphalt emulsion shall be heated at the time of application to a temperature specified by the engineer in accordance with the limits provided in [Sec 1015](#), or as specified in the contract. The tack shall be properly cured and the tacked surface shall be cleaned of all dirt and surplus sand before the next course is placed.

**407.4.3.1** The tack coat shall be applied in such manner as to cause the least inconvenience to traffic and to permit one-way traffic without pickup or tracking of the asphalt emulsion. The tack may be applied full width, provided the tacked surface is blotted with sand in such quantity as specified by the engineer before it is opened to traffic.

**407.5 Method of Measurement.** Measurement of asphalt emulsion to the nearest 10 gallons (50 L) will be made as specified in [Sec 1015](#). If water is added to asphalt emulsion, the

quantity to be paid for will be determined prior to the addition of water. No direct payment will be made for water added to the asphalt emulsion.

**407.5.1** Measurement of material for sanding tack coat will be made to the nearest ton (megagram) of total quantity used. Measurement will be made by weighing (determining the mass of) each truck load on scales conforming to the requirements of [Sec 310.4.3](#).

**407.6 Basis of Payment.** The accepted quantity of tack coat will be paid for at the contract unit price.

**407.6.1** Aggregate used for sanding tack coat, if directed by the engineer, will be paid for at a fixed unit price of \$8.00 per ton (\$8.80/Mg).

## SECTION 408

### PRIME COAT

**408.1 Description.** This work shall consist of preparing and treating an existing surface with bituminous material, and blotter material, if required, in accordance with these specifications and in conformity with the lines shown on the plans or established by the engineer.

**408.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Type RC Liquid	1015
Type MC Liquid Asphalt	1015
Emulsified Asphalt	1015

The type and grade of bituminous material will be specified in the contract. Liquid asphalt may be changed one grade by the engineer during construction at no change in unit price.

**408.2.1** Aggregate used for sanding primer shall be a fine, granular material naturally produced by the disintegration of rock of a siliceous nature, or fines manufactured from igneous rock, chert gravel, limestone or flint sand.

**408.3 Equipment.** The contractor shall provide equipment for heating and applying the bituminous material and for applying blotter material. This equipment shall meet the requirements of [Sec 405](#). Equipment shall include an approved 5-ton (4.5 Mg) roller.

#### **408.4 Construction Requirements.**

**408.4.1 Weather Limitations.** Bituminous material shall not be applied (1) when either the air temperature or the temperature of the surface to be primed is below 60 F (15 C) or (2) when weather conditions prevent the proper construction of the prime coat. Temperatures are to be obtained in accordance with MoDOT Test Method T20.

**408.4.2 Preparation of Surface.** The surface to be primed shall be shaped to the required grade and cross section, shall be free from all ruts, corrugations, segregated material or other irregularities, and shall be uniformly compacted by rolling. The surface shall be firm and slightly damp when primer is applied. Delays in priming may necessitate reprocessing or reshaping to provide a smooth compacted surface.

**408.4.3 Application.** Bituminous material shall be applied to the width of the section to be primed by means of a pressure distributor in a uniform, continuous spread. The application rate shall be as specified in the contract or as revised by the engineer between 0.2 and 0.5 gallon per square yard (0.9 and 2.3 L/m<sup>2</sup>). The primer shall be heated at the time of application to a temperature specified by the engineer in accordance with the limits provided in [Sec 1015](#), or as specified in the contract.

**408.4.3.1** Care shall be taken that the application of bituminous material at the junctions of spreads is not in excess of the specified quantity. Building paper shall be placed over the end of the previous applications and the joining application shall start on the building paper.

Building paper used shall be removed and satisfactorily disposed of. Pools of primer material remaining on the surface after the application shall be removed.

**408.4.3.2** When traffic is maintained, not more than one half of the width of the section shall be treated in one application and one-way traffic will be permitted on the untreated portion of the roadbed. As soon as the bituminous material has been absorbed by the surface and will not pick up, traffic shall be routed to the treated portion and the remaining width of the section shall be primed.

**408.4.3.3** The primer shall be properly cured, and the primed surface shall be cleaned of all dirt and surplus sand before the next course is placed.

**408.4.4 Application of Blotter Material.** If, after the application of the prime coat, the bituminous material fails to penetrate and the roadbed must be used by traffic, sand blotter material shall be spread in the quantity required to absorb any excess bituminous material.

**408.5 Method of Measurement.** Measurement of bituminous material to the nearest 10 gallons (50 L) will be made as specified in [Sec 1015](#).

**408.5.1** Measurement of material for sanding primer will be made to the nearest 1/4 cubic yard (0.2 m<sup>3</sup>) for each load measured in the vehicle at the end of the haul, and to the nearest cubic yard (cubic meter) for the total quantity.

**408.6 Basis of Payment.** The accepted quantities of prime coat will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for furnishing or applying any water required for dampening the surface to be primed.

## SECTION 409

### SEAL COAT

**409.1 Description.** This work shall consist of the application of bituminous material followed by the application of cover coat material in accordance with these specifications and in conformity with the lines shown on the plans or established by the engineer.

**409.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Aggregate for Seal Coats The grade of aggregate will be specified in the contract.	1003
Aggregate for Polymer Modified Asphalt Seal Coats Aggregate for polymer modified asphalt seal coats shall be crushed stone, Grade 3, 4, 5 or 7; or porphyry, Grade 3.	1003
Liquid Asphalt (RC-3000) or (MC-3000)	1015
Asphalt Binder (PG 46-28)	1015
Emulsified Asphalt (RS-2, CRS-2, RS-1 or CRS-1) Unless otherwise specified in the contract, the type of bituminous material and grade of liquid asphalt or asphalt binder may be selected by the contractor from any of those specified above. The grade of emulsified asphalt will be designated by the engineer after examination of the aggregate the contractor proposes to furnish.	1015
Polymer Modified Asphalt Emulsion Unless otherwise specified in the contract, the grade of polymer modified asphalt emulsion shall be either CRS-2P or EA-90P.	1015

**409.2.1** In addition to these requirements, the aggregate and bituminous material shall show satisfactory adhesion when tested for stripping in accordance with MoDOT Test Method T12. Consideration will be given to use of bituminous material to which an anti-stripping agent has been added.

**409.3 Equipment.** The following equipment or its equivalent will be required:

(a) A distributor for heating and applying bituminous material. The distributor shall meet the requirements of [Sec 405.3.2](#).

(b) A rotary power broom.

(c) A minimum of one oscillating-type pneumatic-tire roller. The pneumatic-tire roller shall be self-propelled, weighing from 5 to 8 tons (having a mass of 4.5 to 7.5 Mg). Pneumatic-tire rollers shall be operated at a speed not to exceed 5 miles per hour (8 km/h).

(d) A self-propelled aggregate spreader of approved design. The aggregate spreader shall be equipped with a means of applying the larger cover aggregate to the surface ahead of the smaller cover aggregate and with positive controls so that the required quantity of material will be deposited uniformly over the full width of the bituminous material. Other types of aggregate spreaders may be used only with written approval of the engineer.

#### **409.4 Construction Requirements.**

**409.4.1 Weather Limitations.** Bituminous material shall not be applied when either the air temperature or the temperature of the surface to be sealed is below 70 F (21 C). Bituminous material shall not be applied on a wet surface or when weather conditions would prevent the proper construction of the seal coat. Temperatures are to be obtained in accordance with MoDOT Test Method T20.

**409.4.2 Preparation of Surface.** The surface to be treated shall be thoroughly cleaned and swept to remove all mud, matted earth, dust and other foreign material.

**409.4.3 Application of Bituminous Material.** Bituminous material shall be applied by means of a pressure distributor in a slow, uniform, continuous spread, without missing or overlapping, at a truck speed consistent with the placement of the cover aggregate. Unless otherwise provided, the bituminous material shall be applied to one half the width of the surface at a time, with the center lap of the application placed at the lane line of the traveled way and kept as narrow as is practicable. The other side of the roadbed shall be left open to traffic. The application on one lane shall not exceed that on the adjacent lane by more than 3 miles (5 km). The bituminous material shall be within the temperature range specified by the engineer in accordance with the limits provided in [Sec 1015](#), except that asphalt binder shall be between 315 and 350 F (155 and 175 C). The actual quantity of bituminous material to be used per square yard (square meter) shall be as specified by the engineer. The rate of application is based on the specified minimum residual binder content as it applies directly to asphalt binder. The rate of application of liquid asphalt and emulsified asphalt shall be such that the residual binder content is equivalent to asphalt binder.

**409.4.3.1** The angle of the spray nozzles and the height of the spray bar shall be set to provide a triple coverage fan pattern. The frame of the distributor shall be blocked or snubbed to the axle of the truck to maintain a constant height of the spray bar above the road surface during discharge of the load. An alternate method of maintaining constant spray bar height may be approved.

**409.4.3.2** To ensure uniform application of the bituminous material at the beginning of each distributor load, a portion of the roadbed surface shall be covered with building paper. The area covered by the building paper shall be used as the starting point for each distributor load or each part of a load after a temporary delay. If the cut-off is not positive, the use of paper may be required at the end of each spread. The paper shall be removed and disposed of in a satisfactory manner. The distributor shall be moving forward at proper application speed when the spray bar is opened. Any skipped areas or deficiencies shall be corrected. Junctions of spreads shall be carefully made to ensure a smooth riding surface. The application of bituminous material on adjacent portland cement or asphaltic concrete pavements, curbs, bridges or any areas not specified to be sealed shall be avoided.

**409.4.3.3** If the seal coat is to be constructed on a bituminous surface in which the binder material was other than asphalt binder, the placing of the seal coat will not be permitted until the underlying bituminous course has cured from 15 to 30 days, as directed by the engineer.

**409.4.4 Application of Cover Aggregate.** In general, the cover aggregate shall be placed within two minutes following the application of the bituminous material. Operations shall not proceed in such manner that bituminous material will be allowed to chill, set up, dry or otherwise impair retention of the cover aggregate. The cover aggregate shall be spread by means of a self-propelled mechanical spreader accurately measuring and uniformly spreading the aggregate. The actual quantity of cover aggregate to be used per square yard (square meter) shall be as specified by the engineer. Spreading shall be accomplished in a continuous

manner, without stopping between trucks, and in such manner that the tires of the trucks or aggregate spreader at no time contact the uncovered and newly applied bituminous material. All portions of the surface not covered by mechanical spreaders shall be hand spotted so that the entire surface will be uniformly covered. Light hand brooming may be necessary to distribute excessive aggregate.

**409.4.4.1** If liquid asphalt or asphalt binder is used, cover aggregate shall be surface dry when applied to the bituminous material. Surface dry shall be that condition when no visible film of water exists on the aggregate. If emulsified asphalt is used, the moisture content of the aggregate shall not exceed 5 percent by weight (mass). If specified by the engineer, the cover aggregate shall be moistened with water to enhance cohesive properties of the emulsion.

**409.4.4.2** Rolling shall begin immediately behind the spreader and shall consist of two complete coverages with the pneumatic-tire roller. All rolling shall be completed the same day the cover aggregate is applied.

**409.4.4.3** After the embedded aggregate has set, the surface shall be lightly broomed or otherwise maintained as directed for a period not to exceed four days. Maintenance of the surface shall include the distribution of cover aggregate over the surface to absorb any free bituminous material, and the removal of excess aggregate. Generally, the maintenance shall be confined to the cooler hours of the day and shall be conducted so as not to displace embedded material. The surface shall be free of excess aggregate at the time of acceptance of the work.

**409.5 Traffic Control.** No traffic shall be permitted on the seal coat until all rolling has been completed. The contractor shall control traffic by means of pilot vehicles to a maximum speed of 20 miles per hour (30 km/h) for at least two hours after the completion of rolling. The contractor's supply trucks shall observe these traffic controls. Pilot vehicles shall also be used to maintain one-way traffic through areas of placing and rolling.

**409.6 Method of Measurement.** Measurement of bituminous material, to the nearest 10 gallons (50 L), will be made as specified in [Sec 1015](#).

**409.6.1** Measurement of cover aggregate will be made in accordance with the applicable requirements of [Sec 310.4](#).

**409.7 Basis of Payment.** The accepted quantities of seal coat will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for anti-stripping agent added to the bituminous material. If liquid asphalt or emulsified asphalt is used, the quantity for payment purposes will be reduced by dividing the actual gallons (liters) of bituminous material used by the following factors:

- (a) 1.25 for RC-3000 and MC-3000 Liquid Asphalts.
- (b) 1.82 for RS-1, 1.59 for RS-2, 1.67 for CRS-1 and 1.54 for CRS-2 Emulsified Asphalts.
- (c) 1.54 for CRS-2P and EA-90P Polymer Modified Asphalt Emulsion.

**409.7.1** Any overrun or underrun from the contract quantity shall not be a basis for claim.







# **DIVISION 500**

## ***RIGID PAVEMENTS***





## SECTION 501

### CONCRETE

**501.1 Description.** Concrete shall consist of a mixture of cement, fine aggregate, coarse aggregate and water combined in the proportions specified for the various classes. Admixtures for the purpose of entraining air, retarding or accelerating the set, tinting and other purposes may be added as specifically required or permitted.

#### **501.2 Material.**

**501.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Coarse Aggregate	<a href="#">1005.1</a>
Fine Aggregate	<a href="#">1005.2</a>
Ground Granulated Blast Furnace Slag	<a href="#">1017</a>
Fly Ash	<a href="#">1018</a>
Cement	<a href="#">1019</a>
Concrete Admixture	<a href="#">1054</a>
Concrete Tinting Material	<a href="#">1056</a>
Water	<a href="#">1070</a>

Regardless of the gradation of the coarse aggregates used in concrete for pavement or base, they shall meet the quality requirements of coarse aggregate for concrete pavement.

**501.2.2 Mix Design.** The proportions of cement, fine aggregate and coarse aggregate for concrete shall be as specified by the engineer within the applicable limits of the specifications for the class of concrete specified in the contract. The engineer assumes no responsibility for the volume of concrete produced or furnished for the work.

**501.2.2.1** The proportions for any mixture of material obtained from established and approved commercial sources may be obtained by the contractor from the engineer upon request. If the contractor desires to ascertain the mix for a certain combination of aggregates obtained from commercial sources before construction work starts, the engineer shall be advised in writing of the specific source of material which the contractor desires to use, and the engineer will supply the contractor with the mix for each combination of coarse and fine aggregates for which a specific request is made. If mix design information is desired for bidding, requests for such information may be made to the District Engineer at the District Office or the Division Engineer, Materials, at Jefferson City. The contractor shall make the request as far in advance of the bid opening as possible to allow the engineer sufficient time to furnish a reply. The mix set by the engineer will be based upon the material designated by the contractor as intended for use in the work and, if sources of supply are changed, the mix may be revised if necessary.

**501.2.2.2** For simplicity of design, the various fine aggregates are grouped into four classes, and a minimum and maximum cement factor has been established for each class. The cement factor for the individual job may vary within the maximum and minimum limits, depending upon the gradation of the coarse aggregate, the quantity of mixing water used, the quantity of entrained air when air-entrained concrete is specified and upon changes in proportions which may be necessary to produce satisfactory workability, strength or entrained air content. The

engineer will make such changes in proportions, within the limits of these specifications, as necessary to produce concrete of satisfactory workability and strength.

**501.2.2.3** The cement factor or the quantity of cement used in any cubic yard (cubic meter) of concrete shall be the cement content in sacks per cubic yard (kilograms per cubic meter) of concrete as determined from a summation of the absolute volumes of all the ingredients and, when air-entrained concrete is specified, the volume of air. The cement requirements in sacks per cubic yard (kilograms per cubic meter) of concrete for the various classes of sand are as follows:

Cement Requirements*												
ENGLISH												
Class of Sand	Class A-1 Concrete		Class B Concrete		Class B-1 Concrete		Class B-2 Concrete		Pavement Concrete		Seal Concrete	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
A	6.40	8.00	5.60	6.00	6.50	7.00	7.50	8.00	6.00	6.40	7.00	8.00
B	6.80	8.00	6.00	6.40	6.80	7.20	7.80	8.20	6.20	6.60	7.40	8.00
C	----	----	6.20	6.60	7.00	7.40	8.00	8.40	6.40	6.80	7.60	8.00
D	----	----	6.60	7.00	7.40	7.80	8.40	8.80	6.80	7.20	7.80	8.00
METRIC												
Class of Sand	Class A-1 Concrete		Class B Concrete		Class B-1 Concrete		Class B-2 Concrete		Pavement Concrete		Seal Concrete	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
A	360	450	310	330	360	390	420	450	330	360	390	450
B	380	450	330	360	380	400	430	460	350	370	410	450
C	----	----	350	370	390	410	450	470	360	380	420	450
D	----	----	370	390	410	430	470	490	380	400	430	450

\*When coarse aggregate, Gradation F conforming to [Sec 1005.1.2.5](#) is used, the cement requirements shall be increased 0.50 sacks per cubic yard (30 kg/m<sup>3</sup>) of concrete. When used, Type IP, I(PM), IS or I(SM) cement shall be substituted on a pound for pound (kilogram for kilogram) basis for Type I or Type II cement and adjustment in design mix proportions will be required to correct the volume yield of the mixture.

Class A sand shall include all sand, except manufactured sand, weighing 109 pounds per cubic foot (having a mass of 1740 kg/m<sup>3</sup>) or more.

Class B sand shall include all chert, river and Crowley Ridge sand weighing from 106 pounds to 108 pounds inclusive per cubic foot (having a mass of 1610 kg/m<sup>3</sup> to 1730 kg/m<sup>3</sup> inclusive), or glacial sand weighing 108 pounds or less per cubic foot (having a mass of 1730 kg/m<sup>3</sup> or less).

Class C sand shall include all chert, river and Crowley Ridge sand weighing from 101 pounds to 105 pounds inclusive per cubic foot (having a mass of 1610 kg/m<sup>3</sup> to 1680 kg/m<sup>3</sup> inclusive).

Class D sand shall include all sand weighing 100 pounds or less per cubic foot (having a mass of 1600 kg/m<sup>3</sup> or less) and any manufactured sand which is produced by the process of grinding and pulverizing large particles of aggregate, or which contains more than 50 percent of material produced by the reduction of coarser particles. Manufactured sand produced from limestone or dolomite shall not be used in portland cement concrete for driving surfaces such as bridge decks, pavements and shoulders.

The weight per cubic foot (mass per cubic meter) shall be the dry rodded weight per cubic foot (mass per cubic meter) of the aggregate, determined in accordance with AASHTO T 19.

**501.2.3 Sampling.** Sampling of fresh concrete shall be in accordance with AASHTO T 141, except that for central or truck mixed concrete, the entire sample for slump and air tests and for molding compressive strength specimens may be taken at one time after approximately one cubic yard (cubic meter) of concrete has been discharged, instead of at three or more regular intervals during the discharge of the entire batch. Acceptability of the concrete for slump and air content, and if applicable for strength requirements, will be determined by tests on these samples.

**501.2.4 Consistency.** The slump of the concrete will be specified by the engineer within the following limits for the respective classes of concrete. The concrete shall be uniform in consistency and contain the minimum quantity of water required to produce the designated slump. The slump and mixing water content of the concrete, when placed in the work, shall not exceed the following limits:

Slump and Mixing Water Requirements			
ENGLISH			
Class of Concrete	Max. Slump In.	Maximum Gallons of Mixing Water Per Sack of Cement	
		Air-Entrained	Non-Air-Entrained
A-1	3 ½	5.25	5.75
B	4	5.75	6.25
B-1	4	5.0	6.0
B-2	2 ½	4.5	----
Pavement	2 ½	5.5	6.0
Seal	8	----	6.0
METRIC			
Class of Concrete	Max. Slump mm	Maximum Kilograms of Mixing Water Per Kilogram of Cement	
		Air-Entrained	Non-Air-Entrained
A-1	90	0.46	0.51
B	100	0.51	0.55
B-1	100	0.44	0.53
B-2	60	0.40	----
Pavement	60	0.50	0.53
Seal	200	----	0.53

**501.2.4.1** The slump of B-2 concrete may be increased 1/2 inch (13 mm) to improve workability if permitted by the engineer. The slump of concrete for pavement may be increased to a maximum of 3 1/2 inches (90 mm) if finishing by hand methods is permitted and used, provided the cement content is increased 0.25 sack per cubic yard (15 kg/m<sup>3</sup>) of concrete above that established for the work in accordance with [Sec 501.2.2.3](#).

**501.2.4.2** The slump of concrete mixes will be determined in accordance with AASHTO T 119. The quantity of mixing water in the concrete shall be considered the net quantity after proper allowance has been made for absorption by the aggregates.

**501.3 Measurement of Material.** The cement and aggregates for concrete shall be measured by weight (mass). The weights (masses) of coarse and fine aggregates to be used will be

calculated from the proportions specified by the engineer. Batches which do not contain the proper quantities of material shall be wasted at the contractor's expense.

**501.3.1** The weighing (mass determination) and batching equipment shall be designed and maintained in such condition that the material for each batch can be quickly and accurately weighed (made) and shall be operated within a tolerance of plus or minus 0.5 percent for cement and plus or minus 1.0 percent for aggregates. Scales shall be sufficiently free from vibration to permit accurate weighing (mass determination) when the plant is in operation. If, for any reason, equipment previously approved becomes unsatisfactory, it shall be repaired or replaced before proceeding with the work. When using stationary mixers with a rated capacity greater than 16 cubic feet (0.45 m<sup>3</sup>), storage bins with adequate separate compartments shall be provided for bulk cement, if used, for fine aggregate and for each required size of coarse aggregate. The equipment used for delivery of material to bins shall not permit intermingling of aggregates. Each compartment shall be designed to discharge efficiently and freely into the weighing hopper. Weighing hoppers shall be so constructed that there will be no attachments that might affect the free movement of the weighing mechanism (mass determination). Weighing hoppers shall discharge completely and there shall be no accumulation of tare material. Weighing (Mass determination) and batching equipment shall be supported on a firm foundation. If necessary, the weighing hopper shall be protected against the wind. Scales for weighing (determining the mass of) aggregate or cement may be beam, springless dial or electronic digital weight (mass determination) meter type, and shall be of standard make and design. Scales shall be accurate to within 0.4 percent of the net load applied. The change in load required to change the position of rest of the indicating element or elements of indicating scales an observable amount shall not be greater than 0.1 percent of the nominal scale capacity. Exposed fulcrums, clevises and similar working parts of the scale shall be kept clean. If beam-type scales are used, a separate beam shall be provided for each type of material to be used, and means shall be provided for adjustment of tare. For manually operated plants, provisions shall be made to indicate to the operator that the required load in the weighing hopper is being approached. The device shall indicate at least the last 5 percent of the load weighed (applied) on any beam, except that in no case will this increment be required to be greater than 200 pounds (100 kg). Quantity indicators necessary for batching operations shall be in full view of the operator.

**501.3.2** Cement shall be measured by weight (mass) or by sacks of standard weight (mass). If cement is measured by weight (mass), it shall be weighed (determined) on a scale separate from those used for other material. If cement is measured by sacks, no fraction of a sack shall be used unless weighed (unless the mass has been determined).

**501.3.3** Mixing water shall be measured by volume or by weight (mass). If measured by weight (mass), scales shall conform to the requirements of [Sec 501.3.1](#). The device for the measurement shall be readily adjustable, and under all operating conditions shall measure the required quantity within a tolerance of one quart (one liter) or one percent, whichever is greater. The device shall be so arranged that the flow of water is automatically stopped when the required quantity has been delivered. Water measuring devices shall be of adequate capacity to furnish the maximum quantity of mixing water required, and shall be equipped with outside taps and valves to permit their calibration under conditions similar to operating conditions.

**501.3.4** Personnel, scales and equipment necessary for calibrating the proportioning devices and for verifying the accuracy of proportions shall be furnished by the contractor and shall be available at the proportioning plant at all times. The equipment shall include standard 50-pound (20 kg) test weights equivalent to 20 percent of the net load capacity of the scales, to the nearest greater 50-pound (20 kg) increment. However, not more than twenty 50-pound (20 kg) weights will be required. All equipment shall be calibrated by the contractor in the



presence of and subject to the approval of the engineer. Calibration by an approved commercial scale service may be required in case of large capacity scales of greater than 10,000 pounds (4500 kg) or if scales do not meet calibration tolerances.

**501.4 Mixing.** The concrete mixer shall be of a type approved by the engineer. A mixer used on structural work involving individual pours of 30 cubic yards (25 m<sup>3</sup>) or more shall have a manufacturer's guaranteed capacity of not less than 10 cubic feet (0.3 m<sup>3</sup>), and for smaller pours the mixer shall have a manufacturer's guaranteed capacity of not less than 5 cubic feet (0.25 m<sup>3</sup>).

**501.4.1** The mixer shall produce concrete uniform in color, appearance and distribution of the material throughout the mixture. Variations in the mixed concrete reasonably attributable to worn pickup or throw-over blades will be just cause for inspection of such blades. If such inspection reveals the blades to be worn down more than one inch (25 mm) below the original height of the manufacturer's design, the blades shall be repaired or replaced. A copy of the manufacturer's design, showing dimensions and arrangement of blades, shall be made immediately available to the engineer upon request. The cement, aggregates and not less than 60 percent of the water shall be mixed not less than one minute. The remaining water shall be added within 15 seconds after all other material for the batch are in the mixer. If mixers having multiple compartment drums are used, the time required to transfer material between compartments will be considered mixing time. The speed at which the drum shall rotate shall be as designated by the manufacturer. If such mixing does not result in concrete having a uniform and smooth texture, a sufficient number of additional revolutions at the same speed shall be given until a thorough mixing of each batch of concrete is secured. If a mixer having a rated capacity of more than 38 cubic feet (1 m<sup>3</sup>) per batch is used, the mixing time shall be increased 15 seconds for each additional cubic yard (cubic meter) of capacity, or fraction thereof, except as specifically permitted for central mixers in [Sec 501.5.4](#). The mixing time shall be measured from the time all cement, aggregates and 60 percent of the water, are in the drum. The volume of concrete mixed in each batch shall not exceed the manufacturer's rated capacity.

**501.4.2** The mixer shall be equipped to automatically time the mixing of each batch of concrete. Should the automatic timing device become inoperable, a manual timing device shall be provided to complete the day's operation.

**501.5 Central and Truck Mixed Concrete.** The following additional requirements shall apply to central and truck mixed concrete.

**501.5.1** All central mixers, truck mixers and agitators shall comply with the requirements of these specifications prior to use, and inspections of the equipment will be made periodically during the work. Only equipment found acceptable in every respect and capable of producing uniform results will be permitted.

**501.5.2** If the concrete is to be used in bridge construction, the contractor shall furnish and conform to a schedule of delivery which provides that all batches receive essentially the same mixing and agitation. Failure to deliver consistently uniform concrete will be cause for its rejection and the contractor will be required to furnish concrete produced by a stationary mixer on the job site without any adjustment in the contract unit price.

**501.5.3** Storage facilities for all material shall be designed to permit the engineer to make necessary inspections prior to the batching operations. The facilities shall also permit identification of approved material at all times and shall be designed to avoid any mixing with, or contaminating by, unapproved material. Coarse and fine aggregate shall be so furnished and handled that variations in the moisture content affecting the uniform consistency of the

concrete is avoided. Any aggregate fractions used which vary more than one percentage point from the mean moisture content established near the start of the day's operations on the structure section, when delivered to the weighing hopper during any one pour of concrete, will be subject to rejection. The engineer may permit a change in the mean moisture content, and the moisture content of the aggregate shall then vary not more than one percentage point from the newly established mean. These provisions shall in no way alter the slump and mixing water requirements of the specifications for concrete. The fine aggregate bin or weighing hopper shall be equipped with a moisture sensing device which shall consistently indicate the moisture content within 0.5 percent of the dry weight (mass) of the aggregate. The indicator shall be in such position that it may be readily observed by the operator during batching operations. These requirements for specific limits on moisture variation and for a moisture sensing device are not applicable to pavement concrete.

**501.5.4** Central mixed concrete shall be mixed in a stationary mixer in accordance with the requirements specified herein. Except as otherwise permitted in [Sec 501.5.11](#), it shall be transported to the point of delivery in a truck mixer operating at agitating speed, or in an agitator truck. The mixing time shall be in accordance with the requirements of [Sec 501.4.1](#) or as necessary to produce concrete which meets uniformity criteria when tested as specified in Section 10.3 of ASTM C 94 with the following additions and exceptions:

(a) The two samples shall be obtained within an elapsed time of not more than 15 minutes.

(b) The air content, slump and mix proportions of the concrete tested shall meet the requirements of [Sec 501](#) for that class of concrete or the uniformity tests shall be invalid.

(c) The use of a one-quarter cubic foot (0.007 m<sup>3</sup>) measure will be permitted in determination of weight per cubic foot (mass per cubic meter).

(d) Cylinders may be cured in damp sand after the first 48 hours.

(e) The contractor may designate the mixing time for which uniformity tests are to be performed. The maximum mixing time shall not exceed the mixing time established by uniformity tests by more than 60 seconds for air-entrained concrete. The mixed concrete shall meet the uniformity requirements specified above before any concrete may be used for pavement or structures. However, the engineer may allow the use of the test concrete for appropriate incidental construction. Labor, sampling, sampling equipment and material required for uniformity tests of the concrete mixture shall be furnished by the contractor. The engineer will furnish required testing equipment including scales, cubic measure and air meter. The tests will be performed by the engineer, or by the contractor with approval by the engineer. No direct payment will be made for the labor, equipment, material or testing. After operational procedures of batching and mixing are thus established, no changes in procedure will be permitted without re-establishing procedures by uniformity tests.

**501.5.4.1** Measurement of mixing time shall start at the time all the solid material is in the drum and shall end at the beginning of the next sequential operation. The batch shall be so charged into the mixer that some water enters in advance of the cement and aggregate and all water is in the drum by the end of the first one-fourth of the specified mixing time. Mixer performance tests shall be repeated whenever the appearance of the concrete or the coarse aggregate content of samples selected as set out in ASTM C 94, as modified above indicates that adequate mixing is not being accomplished.

**501.5.5** Truck mixed concrete shall be mixed at the proportioning plant and the mixer shall operate at agitating speed while in transit. However, truck mixed concrete may be mixed at

the point of delivery provided the cement, or cement and mixing water, are added at that point. Mixing of truck mixed concrete shall begin immediately after the introduction of the mixing water to the cement and aggregates, or the introduction of the cement to the aggregate.

**501.5.6** A truck mixer shall consist of a watertight revolving drum suitably mounted and fitted with adequate blades, and equipped with a device for determining the number of mixing revolutions. Truck mixers shall produce a thoroughly mixed and uniform mass of concrete, and shall discharge the concrete without segregation. A truck agitator shall consist of a watertight revolving drum or a watertight container suitably mounted and fitted with adequate revolving blades. Truck agitators shall transport and discharge the concrete without segregation. Mixers and agitators shall be cleaned of accumulations of hardened concrete or mortar.

**501.5.7** Except as hereinafter permitted, each truck mixer shall have permanently attached to it a metal rating plate issued by and in accordance with the capacity requirements of the Truck Mixer Manufacturers Bureau, as approved by NRMCA, on which is stated its maximum capacity in terms of volume of mixed concrete for the various uses to which the equipment is applicable. It shall also have attached a manufacturer's data plate which shall state the actual capacity as an agitator, the maximum and minimum mixing and agitating speeds and any other data desired by the manufacturer. If truck mixers are used for mixing or agitating, the volume of concrete in each batch shall not exceed the maximum capacity shown on the metal rating plate issued by the Truck Mixer Manufacturers Bureau, as approved by NRMCA, except that if a lower capacity for agitating is shown on the manufacturer's data plate, that lower capacity shall govern. If the equipment does not have attached such a rating plate, the batch volume when the equipment is used as a mixer and as an agitator, shall not exceed 57.5 percent and 80.0 percent of the gross interior volume, respectively. The minimum batch size for truck mixers shall be one cubic yard (cubic meter). The right is reserved to reduce the batch size, or reject use of any truck mixer which does not produce concrete uniform in color, appearance and distribution of material throughout the mass. A quantity of concrete which results in axle and gross loads in excess of statutory limits will not be permitted.

**501.5.8** Truck mixers and agitators shall be operated at the speed of rotation designated by the manufacturer of the equipment, provided such speeds are within the following limits. Mixing speed for the revolving drum type of mixer shall be not less than 6 nor more than 18 revolutions of the drum per minute. Agitating speed for both the revolving drum mixers and revolving blade type agitators shall be not less than 2 nor more than 6 revolutions per minute of the drum or of the mixing blades. Truck mixed concrete shall initially be mixed not less than 70 nor more than 100 revolutions of the drum at mixing speed after all of the ingredients, including water, are in the mixer, except that when the batch volume does not exceed 57.5 percent of the gross volume of the drum or 91 percent of the rated maximum capacity, the number of revolutions required for mixing shall not be less than 50 nor more than 100. When a truck mixer or truck agitator is used for transporting concrete that has been completely mixed, agitation of the concrete shall continue during transportation at the speed designated by the manufacturer of the equipment as agitating speed.

**501.5.8.1** Water may be added to the mixture not more than two times after initial mixing is completed. Each time water is added, the drum shall be turned an additional 30 revolutions or more if necessary, at mixing speed, until uniform mixing is accomplished. All water added will be included in determining the effective water in the mixture.

**501.5.9** Water measuring equipment at the plant or central mixer shall meet the requirements of [Sec 501.3.3](#). If the truck mixer is not equipped with a tank and an automatic water measuring device, a calibrated tank or a meter shall be installed on the truck or at the job site for measuring additional water used to obtain satisfactory workability of dry batches. Each

increment of water used shall be measured within a tolerance of one percent of the total effective water required for the batch. Water used to wash the drum of the mixer shall not be used as mixing water.

**501.5.10** Central or truck mixed concrete shall be delivered to the site of the work and discharge shall be completed within 60 minutes for concrete used for bridge deck surfaces, and within 90 minutes for all other concrete, after the beginning of mixing operations. In hot weather or under conditions contributing to quick stiffening of the concrete, the time shall be reduced as specified by the engineer. Concrete shall be discharged without delay and the time required between the start and completion of discharge shall not exceed 15 minutes for bridge deck surfaces. Discharge time for other concrete pours shall not exceed 15 minutes, except that in the case of small pours, the discharge time may be extended as necessary to provide for proper placing and inspection procedures provided the total mixing, delivery and discharge time does not exceed that specified.

**501.5.11** Consideration will be given to permitting the use of non-agitating equipment for the transportation of central mixed concrete, but approval of this procedure, except as qualified in [Sec 502.3.2](#) for use in portland cement concrete pavement, may be granted only when the quantity of concrete is small, the length of haul short and its use does not require high structural strength for satisfactory performance. The discharge of concrete, for other than pavement, transported in non-agitating equipment shall be completed within 45 minutes after introduction of the mixing water to the cement and aggregates. When hauling heated concrete, or under other conditions contributing to quick stiffening of the concrete, the time shall be reduced as specified by the engineer.

**501.5.12** During the time that concrete is being discharged for pours requiring more than one load of concrete, facilities shall be provided to permit constant communication between the site where the concrete is being placed and the proportioning plant.

**501.5.13 Inspection.** Proper facilities shall be provided for the engineer to inspect ingredients and processes used in the manufacture and delivery of the concrete. A Type 1 Field Laboratory meeting the requirements of [Sec 601](#), shall be provided at the proportioning plant. No direct payment will be made for providing the laboratory. Facilities for obtaining representative samples of each fraction of aggregate, cement and each admixture just prior to incorporation into the mix shall be provided by the producer. Aggregate samples may be taken either by sampling the flowing aggregate stream or by belt sampling. The producer shall furnish the necessary equipment and personnel necessary to assist the engineer in obtaining a representative sample.

**501.5.14 Delivery Ticket.** The manufacturer of truck mixed concrete, and of central mixed concrete for use in structures, shall furnish to the engineer with each truck load of concrete before unloading at the site, a delivery ticket on which is shown information concerning the concrete as follows:

- (a) Name of concrete plant.
- (b) Serial number of ticket.
- (c) Date and truck number.
- (d) Name of contractor.
- (e) Specific project, route and county designation.

- (f) Specific class of concrete.
- (g) Quantity of concrete in cubic yards (cubic meters).
- (h) Time when batch was loaded, or of first mixing of cement and aggregates.

**501.6 Volumetric Batched and Continuous Mixed Concrete.** Upon written request by the contractor, the engineer may approve the use of concrete proportioned by volume. If concrete is proportioned by volume, the requirements of [Sec 501](#) with the following modifications shall apply.

**501.6.1** Volume proportioning devices, such as counters, calibrated gate openings or flow meters, shall be available for controlling and determining the quantities of the ingredients discharged. In operation, the entire measuring and dispensing mechanism shall produce the specified proportions of each ingredient.

**501.6.2** All indicating devices that affect the accuracy of proportioning and mixing of concrete shall be in full view of and near enough to be read by the operator while concrete is being produced. The operator shall have convenient access to all controls.

**501.6.3** The proportioning devices shall be calibrated by the contractor in the presence of and subject to the approval of the engineer. Calibration of the cement and aggregate proportioning devices shall be accomplished by weighing (determining the mass of) each component. Calibration of the admixture and water proportioning devices shall be accomplished by weight (mass) or volume. Tolerances in proportioning the individual components are as follows:

Item	Tolerance
Cement, Weight (Mass) percent	0 to +4
Fine Aggregate, Weight (Mass) percent	±2
Coarse Aggregate, Weight (Mass) percent	±2
Admixtures, Weight (Mass) or Volume percent	±3
Water, Weight (Mass) or Volume Percent	±1

**501.6.4** Verification of the proportioning devices may be required any time deemed necessary by the engineer. Verification shall be accomplished by the following procedure:

With the cement meter set on zero and all other controls set for the designated mix, the activated mixer shall discharge mixed material into a 1/4 cubic yard (0.25 m<sup>3</sup>) container measuring 36 x 36 x 9 inches (1000 x 1000 x 250 mm). When the container is level-struck full, making provision for settling the material into all corners, the cement meter must show a discharge equal to the design proportion of cement for 1/4 cubic yard (0.25 m<sup>3</sup>). A tolerance of ±1/8 inch (±3 mm) from the top of the container will be permitted. If correct yield is not obtained, the proportioning devices shall be adjusted to obtain the design mix or the proportioning devices shall be recalibrated as directed by the engineer.

**501.6.5** The rate of water supplied shall be measured by a calibrated flow meter coordinated with the cement and aggregate feeding mechanism, and with the mixer. The rate shall be adjustable in order to control slump at the desired level.

**501.6.6** Liquid admixtures shall be dispensed through a controlled flow meter. A positive means to observe the continuous flow of material shall be provided. If an admixture requires diluting, it shall be diluted and thoroughly mixed prior to introducing it into the dispenser.

When admixtures are diluted, the ratio of dilution and the mixing shall be approved by and performed in the presence of the engineer.

**501.6.7 Mixing.** The concrete mixer shall be approved by the engineer and shall be an auger-type continuous mixer used in conjunction with volumetric proportioning. The mixer shall produce concrete, uniform in color and appearance, with homogeneous distribution of the material throughout the mixture. Mixing time necessary to produce uniform concrete shall be established by the contractor and shall comply with other requirements of these specifications. Only equipment found acceptable in every respect and capable of producing uniform results will be permitted.

**501.6.7.1** The continuous mixer shall be capable of carrying sufficient unmixed dry bulk cement, fine aggregate, coarse aggregate, admixtures and water, in separate compartments, to produce not less than 6 cubic yards (4.5 m<sup>3</sup>) of concrete at the job site. Each batching or mixing unit, or both, shall carry in a prominent place a metal plate or plates on which are plainly marked the gross volume of the unit in terms of mixed concrete, discharge speed and the weight-calibrated constant of the machine in terms of a revolution counter or other output indicator.

**501.6.7.2** The continuous mixer shall be capable of positive measurement of cement being introduced into the mix. A recording meter visible to the operator and equipped with a ticket printout shall indicate this quantity.

**501.6.7.3** The continuous mixer shall provide positive control of the flow of water and admixtures into the mixing chamber. Water flow shall be indicated by a flow meter and be readily adjustable to provide for minor variations in aggregate moisture. The mixer shall be capable of continuously circulating or mechanically agitating the admixtures.

**501.6.7.4** The continuous mixer shall have a one-inch (25.0 mm) maximum size scalping screen over the fine aggregate bin to screen out mud balls, conglomerate lumps or any other contaminant material which could interrupt the flow of fine aggregate during proportioning.

**501.6.7.5** The continuous mixer shall be capable of being calibrated to automatically proportion and blend all components on a continuous or intermittent basis as required and shall discharge mixed material through a conventional chute.

**501.6.8** Storage facilities for all material shall be designed to permit the engineer to make necessary inspections prior to the batching operations. The facilities shall also permit identification of approved material at all times and shall be designed to avoid any mixing with, or contaminating by, unapproved material. Coarse and fine aggregates shall be furnished and handled so that variations in the moisture content affecting the uniform consistency of the concrete will be avoided.

**501.7 High Early Strength Concrete.** The condition under which high early strength concrete may be used shall either meet the written approval of, or be specified by, the engineer. If Type III, high early strength cement is used, the concrete shall be proportioned in accordance with the requirements of [Sec 501.2](#) for the various classes of concrete. If Type I portland cement is used to obtain high early strength concrete, the proportions will be specified by the engineer.

**501.8 Air-Entrained Concrete.** Air content for all classifications of concrete, excluding Class X concrete, shall be determined in accordance with AASHTO T 152, except that a mallet weighing approximately 0.5 pounds (with a mass determination of 0.23 kg) may be used. Air-entrained concrete shall be used for the construction of the following items.

- (a) All retaining walls and all bridge units, except culvert type structures and seal courses.
- (b) Concrete median barriers.
- (c) All piles (not required for cast-in-place concrete piles).
- (d) Concrete pavement.
- (e) Approach slab and paved approach.
- (f) Concrete median and median strip.
- (g) Sidewalk and steps.
- (h) Curb, gutter, curb and gutter and surface drain basins and drains.
- (i) Concrete pedestals for signs, signals and lighting.

At the contractor's option, all other concrete except seal concrete may be air-entrained but only in accordance with the requirements of these specifications.

**501.8.1** If air-entrained concrete is used, the designated quantity of air by volume shall be 5 1/2 percent, or 6 percent when coarse aggregate Gradation F conforming to [Sec 1005.1.2.5](#) is used, with an operating tolerance of 1 1/2 percentage points. There shall be no intentional deviation from the designated air content. An occasional deviation in air content exceeding the operating tolerance may be permitted if, in the judgment of the engineer, the deviation is such that it will not seriously affect the serviceability of the concrete.

**501.8.2** To avoid wide fluctuations in air content, the contractor shall maintain close control over uniformity of cement, aggregates, consistency of the concrete, operation of proportioning and mixing equipment and mixing time. Air entrainment shall be obtained by use of an approved air-entraining admixture added in the quantity required to obtain the designated air content. It shall be the contractor's responsibility to determine and use the quantity of admixture necessary to obtain the designated air content within the permitted operating tolerance.

**501.8.3** Air-entraining admixtures shall be added to the concrete during the process of mixing. The admixture shall be of such volume and strength that it can be accurately measured and dispensed by means of an approved mechanical dispenser which will gradually discharge the required quantity of material into the stream of mixing water. The entire quantity of air-entraining admixture shall be fully discharged before all of the mixing water has entered the drum of the mixer. The device shall be so arranged that the flow of air-entraining admixture will be automatically stopped when the required quantity has been delivered. The dispenser shall be so constructed that it can be accurately calibrated at various settings and shall be provided with means by which the discharge can be readily diverted from the stream of mixing water to a container for measurement. The dispenser shall consistently deliver the required quantity of admixture within a tolerance of plus or minus 3 percent.

**501.9 Concrete Admixtures for Retarding Set.** If specified in the contract, an approved retarding admixture shall be provided and incorporated into the concrete. If not specified in the contract, the use of an approved retarding admixture may be permitted upon written request by the contractor. Approval for the use of any retarding admixture will be contingent



upon satisfactory performance and permission for its use may be withdrawn at any time satisfactory results are not obtained. The use of a retarding admixture for extending the delivery or discharge time of the concrete, or for modifying temperature requirements for placement, will not be approved. Retarding admixture shall be added in accordance with [Sec 501.8.3](#) by means of a dispenser conforming to the requirements of that section. If both retarding and air-entraining admixtures are used, the sequence and rate of discharge of both materials shall be as specified by the engineer. No direct payment will be made for furnishing the retarding admixture or incorporating it into the mixture.

**501.10 Water-Reducing Admixtures.** At the option of the contractor, Type A water-reducing admixtures may be used in any concrete. High range water-reducing admixtures will not be permitted.

**501.11 Trial Batches.** Prior to placement of any concrete in the work, the contractor may be required to prepare trial batches of concrete for tests. The mixing equipment, mixing time, material, proportions, slump and batch size shall be the same as those to be used during the construction. The batches shall be agitated in such manner to simulate the proposed time of haul and discharge. The volume of all concrete prepared for trial batches which are not used in the work will be determined from the summation of the absolute volumes of all ingredients, and the volume of entrained air when used. Payment will be made at 50 percent of the contract unit price for the class of concrete for which the trial batches were prepared.

**501.12 Calcium Chloride.** The use of calcium chloride or other approved accelerating admixtures in concrete mixtures will not be permitted, except in concrete used for pavement repair, [Sec 613](#).

**501.13 Fly Ash and Ground Granulated Blast Furnace Slag (GGBFS) in Concrete.** The contractor may use fly ash or GGBFS in the production of concrete in accordance with these specifications. Fly ash and GGBFS shall not be intermixed.

**501.13.1** Approved Class C or F fly ash may be used to replace a maximum of 15 percent of Type I or II cement and a maximum of 10 percent of Type IP or I(PM) cement, only when made with a natural pozzolan, on a pound for pound (kilogram for kilogram) basis in all concrete except concrete designed for high early strength. Approved GGBFS may be used to replace a maximum of 25 percent of Type I or II cement on a pound for pound (kilogram for kilogram) basis in all concrete except concrete designed for high early strength.

**501.13.1.1** Fly ash shall not be used as a replacement for Type III, IP, I(PM), IS or I(SM) cement with the following exception. When the Type IP or I(PM) cement is made with a natural pozzolan and not fly ash, fly ash may be used as a replacement as limited herein.

**501.13.1.2** Changes in class or source of fly ash or source of GGBFS used in concrete structures will be permitted only with the written approval of the engineer. Only fly ash or GGBFS resulting in concrete of the same color shall be used in any individual unit of the structure.

**501.13.1.3** Fly ash or GGBFS, Type IS or I(SM) cement, or Type IP or I(PM) cement made with fly ash pozzolan shall not be used in pavement concrete placed between November 1 and April 1. These date restrictions do not apply to Type IP or I(PM) cement made with a natural pozzolan.

**501.13.2** All proportioning, air-entraining, slump, maximum mixing water requirements, mixing, sampling, measurement of material, transporting of concrete and all material shall be in accordance with [Sec 501](#).



**501.13.3** When fly ash or GGBFS is used, an adjustment in design mix proportions will be required to correct the volume yield of mixture. Mix design shall be as specified by the engineer. Approval shall be obtained from the engineer prior to any change in mix design or proportions.

**501.13.4** Maximum mixing water shall be based on total cementitious material. Ninety-four pounds (42.6 kg) of cementitious material will be considered a sack or bag. The quantity of mixing water in the concrete shall be considered the net quantity after proper allowance has been made for absorption by the aggregates.

**501.13.5** Fly ash or GGBFS shall be stored in separate enclosed storage silos during batching operations.

**501.13.6** Fly ash or GGBFS shall be measured in the same manner and with the same accuracy as cement. (The mass determination of) Fly ash or GGBFS may be weighed (determined) separately on the same scale as cement provided the scale increments are such that the specified weighing (mass determination) accuracy can be maintained. If, however, the (mass of) fly ash or GGBFS is weighed (determined) together with the cement, the (mass of) cement shall be weighed (determined) first and the accuracy shall apply to the combined weight (mass).

**501.13.7** Fly ash or GGBFS shall be considered as cement when measuring mixing time.

**501.13.8** When a commercial mixture of concrete is allowed and fly ash or GGBFS is used, the contractor shall notify the engineer of the class, source and quantity of fly ash proposed or the source and quantity of GGBFS proposed, in addition to the other requirements of [Sec 501](#). The fly ash or GGBFS shall be from an approved source. The quantity of fly ash shall not exceed 15 percent and the quantity of GGBFS shall not exceed 25 percent, by weight (mass), replacement of the cement.

**501.14 Commercial Mixture.** If specified in the contract that an approved commercial mixture of concrete may be used, the contractor shall notify the engineer in writing, setting out for approval the source and proportions of the mixture proposed to be furnished. The statement shall include the following:

- (a) The types and sources of aggregates.
- (b) Type and source of cement and other cementitious material.
- (c) Scale weights (masses) of each aggregate proposed as pounds per cubic yard (kilograms per cubic meter) of concrete.
- (d) Quantity of water proposed as pounds or gallons per cubic yard (kilograms or liters per cubic meter) of concrete.
- (e) Quantity of cement proposed as sacks per cubic yard (cubic meter) of concrete. If the cement is to be measured by the sack, the weight (mass) per sack shall be shown.

The concrete shall contain not less than 517 pounds (305 kg) of cement per cubic yard (cubic meter). The plant shall meet the requirements of [Sec 501](#), or as approved by the engineer. The concrete will be subject to acceptance or rejection by visual inspection at the job site.

**501.14.1** The supplier shall furnish a certification with the first truck load of each day's production of concrete certifying that the material and mix proportions used are in conformance with the approved mixture. Upon completion of the work, plant certification shall be furnished by the supplier for the total quantity delivered.

**501.14.2** Concrete meeting the material and proportioning requirements for Class B concrete will be acceptable as an approved commercial mixture and may be certified to as such.

## SECTION 502

### PORTLAND CEMENT CONCRETE PAVEMENT

**502.1 Description.** This work shall consist of a pavement composed of portland cement concrete, with or without reinforcement as specified, constructed on a prepared subgrade in accordance with these specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer.

**502.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Steel Wire Fabric for Concrete Pavement	<a href="#">1036.2</a>
Concrete Curing Material	<a href="#">1055</a>
Material for Joints	<a href="#">1057.1</a>

All material, proportioning, air-entrainment, mixing, slump and transporting for portland cement concrete shall be in accordance with [Sec 501](#).

**502.3 Equipment.** Equipment and tools necessary for handling material and performing all parts of the work shall be satisfactory to the engineer as to design, capacity and mechanical condition. The equipment shall be at the job site sufficiently ahead of the start of construction operations to be examined thoroughly by the engineer and shall comply with the following requirements.

**502.3.1 Batching Plant and Mixer.** The mixer, water measuring equipment and weighing (mass determination) and batching equipment shall conform to the requirements of [Sec 501](#).

**502.3.2 Hauling.** Trucks for transporting mixed concrete shall meet the requirements of [Sec 501](#). Consideration will be given for the use of an approved type of non-agitating equipment for transporting central mixed concrete provided the discharge of the concrete is completed within 30 minutes after the introduction of the mixing water to the cement and aggregates. Bodies of non-agitating hauling equipment shall be smooth, mortar-tight metal containers capable of discharging the concrete at a satisfactory, controlled rate without segregation.

**502.3.3 Forms.** Side forms, except as otherwise permitted, shall be of metal, with a base width sufficient to support the finishing equipment to be used. The height shall be equal to the edge thickness of the pavement. Each form section shall be straight and free from bends and warps. No section shall show a variation greater than 1/8 inch (3 mm) in 10 feet (3 m) from the true plane surface on the top, and 1/4 inch (6 mm) in 10 feet (3 m) along the face of the form. The method of connecting form sections shall ensure a tight, neat joint. Forms shall be clean and coated with a form release agent before concrete placement.

**502.3.3.1** Forms for curved form lines shall comply with the grade and alignment requirements of [Sec 502.5.1](#), except that straight steel form sections 10 feet (3 m) or less in length may be used for form lines having a radius greater than 200 feet (60 m). Special forms of wood or steel will be permitted for curved form lines having a radius of 200 feet (60 m) or less, and may be permitted if approved by the engineer in other special cases where it is not practicable to use standard pavement forms. Straight steel form sections 5 feet (1.5 m) long will be acceptable for curved form lines having a radius of not less than 100 feet (30 m).

Forms shall be of sufficient rigidity to prevent distortion in edge alignment due to pressure of the concrete. Wood forms shall not be used as a track for operating paving and finishing equipment.

**502.3.4 Vibrators.** Vibrators used for full width vibration of the concrete shall be of the internal type. They shall not come in contact with the reinforcement, load transfer devices, subgrade or side forms. Vibrating equipment shall be operated in accordance with the manufacturer's recommendation at a frequency to provide satisfactory results, but shall not be less than 4500 impulses per minute. Hand vibrators shall have a frequency of not less than 4500 impulses per minute. The contractor shall have a satisfactory tachometer available at all times for checking the vibration frequency.

#### **502.3.5 Surface Finishing Equipment.**

**502.3.5.1 Wire Comb.** A wire comb shall not be less than 10 feet (3 m) long with a single line of wires exposed to a length of approximately 4 inches (100 mm). The wire shall be blue tempered and polished spring steel with nominal dimensions of 0.028 inch (0.71 mm) thick and 0.100 to 0.125 inch (2.54 to 3.175 mm) wide. The wires shall be spaced to provide 1/2 inch (13 mm) clear space between wires and securely mounted in a rigid head with the width of each wire parallel to the longitudinal centerline of the head. Except for pavements finished by hand methods, the wire comb shall be mechanically operated with the length of the comb parallel to the pavement centerline and capable of traversing the full width of pavement in a single pass, at a uniform speed and at a uniform depth. Final approval of the wire comb will be based on satisfactory performance during actual use. Texturing equipment, other than a wire comb, may be approved provided it produces a texture equivalent to that produced by a wire comb and upon satisfactory performance during actual use.

**502.3.5.2 Fabric Drag.** If the contract specifies concrete to be tinted, a fabric drag consisting of a seamless strip of burlap or cotton of not less than the width of the pavement shall be provided. To obtain a satisfactory finish, it may be necessary to ravel out the cross threads of the trailing 2 or 3 inches (50 or 75 mm) of the drag. Brooms of an approved type may be provided in lieu of the fabric drag. The brooms shall not be less than 18 inches (450 mm) wide, made from good quality bass or bassine fiber not more than 5 inches (125 mm) long.

**502.3.6 Concrete Saw.** If sawed joints are required, equipment shall be provided complete with either an abrasive wheel or a diamond-edge water-cooled blade, capable of providing a groove of the specified dimensions in the hardened concrete.

**502.3.7 Equipment for Sealing Joints.** An approved double boiler-type heating kettle equipped with a mechanical agitator and a satisfactory temperature indicating device will be required. The equipment shall be capable of heating the joint sealing material uniformly without damage.

**502.3.8** Auxiliary equipment shall be available at all times as follows:

(a) Two footbridges so designed that they can be readily transported from place to place and which have no part in contact with the pavement.

(b) Long-handled floats, each having a blade at least 3 feet (900 mm) long and 6 inches (150 mm) wide.

(c) Metal dyes with beveled face numerals not less than 3 inches (75 mm) nor more than 5 inches (125 mm) high and thick enough to make an indentation of 1/4 inch (6 mm). A satisfactory dye shall be used for marking the point designated by the station number.

(d) Sufficient burlap, waterproof paper or plastic film for the protection of the pavement in case of rain or breakdown of the curing equipment.

(e) A manually operated long handle wire comb approximately 2 feet (600 mm) wide with wire size and spacing in accordance with the requirements of [Sec 502.3.5.1](#).

**502.3.9 Field Laboratory.** The contractor shall provide a Type 4 Field Laboratory meeting the requirements of [Sec 601](#). No direct payment will be made for providing the laboratory.

### **Construction Requirements**

**502.4 Weather Limitations.** Unless otherwise authorized in writing by the engineer, mixing and concreting operations shall be discontinued when a descending ambient temperature away from artificial heat reaches 40 F (5 C) and not resumed until an ascending ambient temperature away from artificial heat reaches 35 F (2 C). If approval has been granted for the contractor to place the concrete while the ambient temperature is at or lower than 40 F (5 C), the contractor shall take precautionary measures to prevent damage by freezing, such as heating mixing water, heating aggregates or applying heat directly to the contents of the mixer. Aggregates shall not be heated higher than 150 F (65 C), and the temperature of the aggregates and mixing water combined shall not be higher than 100 F (40 C), when the cement is added. Unless otherwise authorized, the temperature of the mixed concrete when heating is employed shall not be less than 50 F (10 C) and not more than 80 F (30 C) at the time of placement. Cement or fine aggregate containing lumps or crusts of hardened material or frost shall not be used. Concrete shall not be placed upon a frozen subgrade except with written approval of the engineer.

**502.4.1 Protection.** All concrete shall be effectively protected from freezing for a period of at least 5 days after it has been placed or until a minimum compressive strength of 3000 pounds per square inch (21 MPa) has been attained. Protection will be required for not more than 10 days. Regardless of precautions taken, the contractor shall assume all risks, and all frozen concrete shall be replaced at the contractor's expense.

**502.5 Setting Forms.** Forms shall be set so that they rest firmly throughout their length upon the thoroughly compacted subgrade. Any subgrade which is more than 1/2 inch (13 mm) below the established grade at the form line shall be brought to grade for a sufficient width, outside the area required by the pavement, to support the forms adequately, and shall be thoroughly rolled. Any variations, whether below or above grade, shall be brought to true grade.

**502.5.1** Paving forms shall be sufficiently supported to avoid displacement during paving operations. Both straight and curved forms shall be supported in such position that the face of the form shall be vertical on tangents and perpendicular to the superelevated section on curves. The top of the form shall not vary more than 1/8 inch (3 mm) from the true grade line during placing, compacting and finishing operations. The form alignment shall not vary more than 1/4 inch (6 mm) from the true alignment.

**502.5.2** Forms shall be set ahead of concrete placement a sufficient distance to provide time to check their line and grade and provide continuous paving operation.

**502.6 Conditioning of Subgrade.** When forms have been securely set to grade, the subgrade shall be brought to proper cross section in accordance with [Sec 209](#). The final checking for proper crown and elevation of the subgrade shall be performed in the presence of the engineer

after all equipment traffic on the subgrade has ceased and as close as is practicable to the area of concrete placement.

**502.6.1** Low areas of treated bases shall be filled only with concrete integral with the pavement. No direct payment will be made for the concrete used to fill these low areas.

**502.7 Proportioning and Mixing Concrete.** Concrete shall be proportioned and mixed by truck or central mixers in accordance with [Sec 501](#). This shall consist of batching all aggregate, cement and water by means of automatic weighing (mass determination) or metering, with all additives dispensed automatically and interlocked with the automatic weighing (mass determination) or metering controls. For central mixed concrete, the mixing cycle shall be timed and interlocked with the weight (mass) batch cycle. The weight (mass determination) setting controls shall be equipped so that they may be locked when directed by the engineer. The automatic batching equipment shall be capable of conversion to manual operation if necessary. Manual operation will not be permitted beyond 24 hours after breakdown in the automatic equipment, except by written approval of the engineer. Where a project includes paving that cannot be performed in a normal sequence, the contractor will be permitted to place up to a maximum of 7000 square yards (5800 m<sup>2</sup>) using manual batching methods.

**502.7.1** For all contracts having a total of not more than 20,000 square yards (16700 m<sup>2</sup>) of concrete base course and concrete pavement combined, manual batching methods will be permitted.

**502.7.2** For all contracts having a total of more than 20,000 square yards (16700 m<sup>2</sup>) of concrete base course and concrete pavement combined, automatic, fully interlocked batching control approved by the engineer will be required.

**502.8 Placing Concrete.** The concrete shall be deposited over the entire width of the subgrade between forms in such manner as to prevent segregation and to require as little rehandling as practicable. Mixers used for pavement construction, including truck mixers and trucks used for transporting concrete, will not be permitted to discharge concrete by chute or by dumping directly on the subgrade, prepared base or previously placed concrete except for areas to be hand finished or for isolated pavement lanes less than 2000 feet (600 m) long. Concrete shall be thoroughly vibrated along the forms or sides and along expansion and key type longitudinal joints. Attachments on finishing machines to vibrate the concrete adjacent to forms and longitudinal joints will be permitted provided satisfactory results are attained. Care shall be taken that the vibrator does not penetrate the subgrade or dislodge or move the joints. The vibrating shall be sufficient to produce a smooth pavement edge. Honeycomb in the edge may be cause for rejection of the pavement.

**502.9 Strike-off of Concrete and Placement of Reinforcement.** Following the placing of the concrete, it shall be struck-off so that when the concrete is properly consolidated and finished, the surface of the pavement will be at the proper elevation and cross section. Reinforced concrete pavement shall be placed in two layers. The entire width of the bottom layer shall be struck-off to such length and depth that the sheet of wire fabric may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall be placed directly upon the concrete, and the top layer of the concrete placed, struck-off and screeded. Any portion of the bottom layer of concrete which has been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the contractor's expense.

**502.9.1** Tie bars shall be supported in the proper position by chairs driven into the subgrade, or may be placed by approved mechanical methods prior to the consolidation of the concrete after it has been struck-off.

**502.9.2** Wire fabric and tie bars shall be free from dirt, oil, paint, grease, loose mill scale and thick rust which could impair bond of the steel with the concrete. Thin, powdery rust need not be removed.

**502.10 Final Strike-off, Consolidation and Finishing.** Machine finishing by extrusion methods or by vibrating and screeding processes will be required for all pavement except as permitted by [Sec 502.10.7](#). After the final course of the concrete has been placed, it shall be struck-off and thoroughly vibrated until concrete of a uniform and satisfactory density is attained. The surface of the pavement shall be of uniform texture and to the proper grade and typical section. Excessive screeding over a given area shall be avoided. Finishing machines shall be kept in satisfactory repair and adjustment and shall be operated without lift, wobbling, or other variation tending to affect a precision finish. While operating, a roll of concrete shall be maintained in front of the full length of all screeds so that the vibrating and screeding work will be fully effective.

**502.10.1 Consolidation.** Concrete shall be consolidated by vibrating the mixture promptly following placement. Vibrating tubes shall extend into the concrete the distance necessary to provide adequate consolidation. Vibrators shall be operated only when the machine to which they are attached is moving.

**502.10.2 Added Finishing Water.** Moisture shall not be applied to the surface of the pavement in any form except for emergency conditions. When emergency conditions exist and it becomes necessary to apply additional moisture to the surface of the pavement in order to complete the final finishing operation, water may be applied but only in the form of a fine pressure spray. Under such conditions, placement of additional concrete on the subgrade shall be discontinued until the emergency conditions cease to exist.

**502.10.3 Surface Finish.** After surface irregularities have been removed, the concrete shall be given a uniformly roughened surface finish by use of a wire comb or other approved texturing device which produces a texture similar to that produced by a wire comb. Successive passes of the comb or other approved device shall be overlapped the minimum necessary to attain a continuously textured surface. The surface texture produced shall have the characteristics of a texture produced using a wire comb as specified in [Sec 502.3.5.1](#), and which has an average texture depth of approximately 0.125 inch (3 mm). Small or irregular areas, or areas not suitable for machine texturing when adjacent surrounding concrete is ready for texturing, may be textured with a hand operated device producing a textured surface equivalent to that required for machine combing.

**502.10.4 Edging at Forms and Joints.** After the final finish, but before the concrete has taken its initial set, the edges of the pavement along each form line, and on each side of transverse expansion joints and construction joints shall be worked with an edging tool having a radius of approximately 3/8 inch (10 mm). A well-defined and continuous radius having a smooth, dense finish shall be produced. The surface of the pavement shall not be unduly disturbed by tilting of the tool during use. Tool marks on the pavement shall be eliminated by brooming or dragging the surface. In doing this, the rounding of the corner of the pavement shall not be disturbed. All concrete on top of the joint filler shall be completely removed. All joints shall be tested with a straightedge before the concrete has set, and correction made if one side of the joint is higher than the other.

**502.10.5 Station Numbers.** The contractor shall indent station numbers into all pavement immediately following the final finishing operations and before the concrete takes its final set. The numbers shall be placed at alternating full stations as ascertained by measurements determined by the engineer. Equations in stationing shall also be marked in the pavement. On undivided pavement, the station numbers shall be on the left side of the pavement with respect to the ascending stationing and shall be on the pavement edge unless an integral curb is involved, in which case the numbers shall be placed on the face of the curb. On divided pavement, station numbers shall be placed on the median side of each pavement. The numbers shall be placed facing the centerline of the pavement, or the centerline of each pavement in the case of divided pavements. The numbers shall be placed on a troweled area of the finished surface. No direct payment will be made for marking station numbers.

**502.10.6 Modified Machine Finishing.** For isolated pavement lanes over 200 feet (60 m) long but less than 2000 feet (600 m) long, all machine finishing equipment will be required except that a mechanical spreader will not be required. The final surface texture may be applied manually with a wire comb meeting the requirements of [Sec 502.3.8](#).

**502.10.7 Hand Finishing.** Compacting and finishing pavement by hand methods will be permitted:

(a) For all curves having a form line radius of less than 200 feet (60 m) or where wood forms are used.

(b) For all irregular shaped areas.

(c) For pavement lanes less than 200 (60 m) feet long.

(d) For pavement lanes less than 10 (3 m) feet wide.

(e) For bridge approach and pavement to first expansion joint.

(f) When a breakdown of the mechanical compacting and finishing equipment occurs or in the event of some other emergency. After a breakdown, only material which has already been proportioned and which may become unsatisfactory for use may be finished by hand.

**502.10.7.1** Hand finishing shall consist of all operations required under [Sec 502.10](#) except mechanical finishing equipment will not be required. The final surface texture may be applied manually with a wire comb meeting the requirements of [Sec 502.3.8](#).

**502.11 Joints.** Joints shall be of the specified type and dimensions, and constructed at the locations shown on the plans or as approved by the engineer. Where joints are preformed, the form or joint shall be set and securely fastened to ensure the joint being in the required position when the concrete is finished. Dowels and tie bars in their final position shall be parallel to the subgrade and perpendicular to the line of the joint. Dowel supporting assemblies shall conform to one of the types shown on the plans. The concrete shall be placed so that it will not displace or disarrange the joint installations.

**502.11.1 Expansion Joints.** Expansion joints shall extend for the full cross section of the concrete pavement. Filler placed prior to the placement of the concrete shall be installed with a removable cap or edging bar to serve as a guide for edging the joint and protection for the filler during the placing and finishing of the concrete. Joints constructed after the placement of concrete shall be sawed full depth and the exposed edges shall be ground to a chamfer of 3/8 inch (10 mm). The filler shall rest snugly on the subgrade from form to form. The joints



shall be sealed as specified in [Sec 502.11.4](#). Upon removal of the forms, any struts or fins of concrete extending across the joint shall be removed to the full width of the joint and the full thickness of the pavement.

**502.11.2 Construction Joints.** Construction joints shall be made at the close of each day's work or when the work is stopped or interrupted for more than 30 minutes. No transverse construction joint shall be constructed within 10 feet (3 m) of an expansion or contraction joint. For transverse contraction joint spacing of 20 feet (6 m) or less, the transverse construction joint shall be located within the normal sequence of contraction joint spacing as shown on the plans. Construction joints shall be constructed perpendicular to the top surface and the centerline of the pavement. Construction joints may be formed with a timber header or may be sawed full depth. The final joint shall conform to the cross section of the pavement. Before paving operations are resumed, all surplus concrete and other refuse shall be removed from the subgrade.

**502.11.3 Sawing.** Unless otherwise provided, all transverse contraction and all longitudinal joints in the pavement shall be sawed with the joint groove cut to the dimensions shown on the plans. If the groove for poured type transverse joints is cut prior to removal of the forms, the groove shall be cut as close as is practicable to the pavement edge, and the resulting crescent shaped plug in the groove, immediately adjacent to the form, will be acceptable. For intersections and irregular pavement, joints shall be sawed at locations as approved by the engineer. Sawing of the joints shall begin as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling. All joints shall be sawed before uncontrolled shrinkage cracking takes place. The sawing of any joint shall be omitted if a crack occurs at or near the joint location prior to the time of sawing. Sawing shall be discontinued when a crack develops ahead of the saw. The engineer reserves the right to have the contractor install preformed type joints on multiple width construction when the use of sawed joints fails to prevent random cracking. Any non-reinforced concrete pavement with random cracking not controlled by dowels or tie bars shall be removed and replaced using dowels or tie bars as appropriate to the nearest controlled joint at the contractor's expense.

**502.11.4 Sealing Joints.** All sawed contraction joints and sawed or formed expansion joints shall be sealed with joint sealing material before the pavement is opened to any traffic, including construction traffic. Immediately prior to sealing, the joints shall be thoroughly cleaned and dried. The sealing material shall be heated to the pouring temperature recommended by the manufacturer. Any material which has been heated above the maximum safe heating temperature will be rejected. The sealing material shall be installed in such a way as to fill the joint opening uniformly from the bottom to approximately 1/8 inch (3 mm) from the top. Any excess material shall be removed from the pavement surface.

**502.11.5 Joint Filler at Railroad Crossings.** Bituminous filler for use between railroad crossing approach slabs and the timber crossing shall be an approved commercial bituminous mixture meeting the requirements of [Sec 401.3.8](#). The mixture shall be tamped into a firm and compacted state.

**502.12 Curing.** Immediately after the finishing operations have been completed and as soon as marring of the concrete will not occur, the entire surface and exposed edges of the newly placed concrete shall be covered and cured in accordance with one of the following methods. The concrete shall not be left exposed for more than 30 minutes between stages of curing or during the curing period.

**502.12.1 White Pigmented Membrane.** After the free water has left the pavement surface, the entire surface shall be sealed by hand or machine spraying with a uniform application of white pigmented membrane curing material. The contractor shall provide satisfactory

equipment to ensure uniform coverage of curing material, without loss, on the pavement at the rate of one gallon for each 150 square feet (0.27 L/m<sup>2</sup>). If rain falls on the newly coated pavement before the film has dried sufficiently to resist damage, or if the film is damaged in any other way, the contractor will be required to apply additional curing material to the affected portions. All areas cut by finishing tools subsequent to the application of the curing material shall immediately be given new applications at the rate specified above. If hair-checking develops before the membrane can be applied, the concrete shall be initially cured with wet burlap as specified in [Sec 502.12.3](#) before the membrane is placed.

**502.12.2 Waterproofed Paper, Polyethylene Sheeting and Polyethylene-Burlap Sheeting.**

As soon as the concrete has set sufficiently to prevent marring, the top surface of the pavement shall be covered with units of waterproofed paper, white polyethylene sheeting or white polyethylene-burlap sheeting, which shall be lapped not less than 18 inches (450 mm). If polyethylene-burlap sheeting is used, the burlap shall be thoroughly dampened prior to placing and shall be placed next to the concrete. All coverings shall be so placed and weighted that they remain in contact with the pavement surface and edges for not less than 72 hours after the concrete has been placed. If hair-checking develops before the covering can be applied, the concrete shall be initially cured with wet burlap as specified in [Sec 502.12.3](#) before the covering is placed.

**502.12.3 Burlap.** The top surface of the pavement shall be temporarily covered with thoroughly damp burlap after the concrete has set sufficiently to prevent marring of the surface. Burlap shall be handled in such manner that contact with earth or other deleterious substances is avoided. All new or contaminated burlap and all burlap which has been used for purposes other than the curing of concrete shall be thoroughly washed before being used. The burlap shall be kept thoroughly wet until removed for application of the final curing material. Neither the top nor the edge of the pavement shall be left unprotected for more than 30 minutes. When the burlap is removed, curing shall be continued by one of the approved methods.

**502.13 Removing Forms.** Forms shall be removed carefully so as to avoid damage to the pavement. Honeycombed areas will be considered as defective work and shall be immediately repaired. If the forms are removed prior to 72 hours after placing concrete, the sides of the pavement shall be cured by one of the methods specified above. Any trench excavated for the forms shall be entirely backfilled so no water will stand next to the pavement.

**502.14 Surface Test.** As soon as practicable, the pavement surface shall be thoroughly tested by profilographing or straightedging as indicated. Testing applicable to this specification, except straightedging, shall be performed by the contractor in the presence of the engineer.

**502.14.1 Profilographing.** Profilographing is applicable to the surface of all mainline paving, auxiliary lanes, turning lanes and ramps. Specifically excluded are:

- (a) Bridge decks and their approach slabs.
- (b) Pavement on horizontal curves with centerline radius of curve less than 1000 feet (300 m) and pavement within the superelevation transition of such curves.
- (c) Pavement on vertical curves having a "K" value less than 90 and a length less than 500 feet (150 m).
- (d) Contracts or stages of construction with less than one half mile (0.8 kilometers) of continuous concrete pavement.

(e) Width transitions.

(f) Fifty feet (15 m) in direction of travel on each side of utility appurtenances such as manholes and valve boxes.

(g) Fifty feet (15 m) in direction of travel on each side of intersecting routes with special grade transition.

(h) Portland cement concrete shoulders.

(i) Any portland cement concrete lane which abuts an existing lane not constructed under the same contract.

**502.14.1.1** Pavement profiles shall be taken 3 feet (1 m) from and parallel to each edge of pavement for pavements 11 feet (3.5 m) wide. If pavement is placed at a greater width than 11 feet (3.5 m), the profile shall be taken 3 feet (1 m) from and parallel to each edge and 3 feet (1 m) to one side of each plan longitudinal joint as directed by the engineer.

**502.14.1.2** Additional profiles shall be required only to define the limits of an area representing deviations greater than 0.40 inch (10 mm), except as required in [Sec 502.14.6.4](#).

**502.14.1.3** A profilogram shall be made for each continuous section of 50 feet (15 m) or more for each days placement. A section is defined where paving begins and terminates at a days work joint, a bridge or other interruption designated by the engineer. Sections will be divided into segments of 0.1 mile (0.1 km) with the exception of the last segment which normally will be less than 0.1 mile (0.1 km).

**502.14.1.4** Individual sections shorter than 50 feet (15 m) and the last 15 feet (5 m) of any section where the contractor is not responsible for the adjoining surface, will be straightedged in accordance with [Sec 502.14.2](#).

**502.14.1.5** If there is a segment of 250 feet (75 m) or less in length at the end of a section, the profilogram for that segment shall be included in the evaluation of the adjacent segment in that section.

**502.14.1.6** If there is an independently placed section of a length between 50 and 250 feet (15 m and 75 m), a profilogram shall be made for that section and included in the evaluation of the most recently placed adjacent segment.

**502.14.1.7** The contractor shall furnish the profilogram and its evaluation to the engineer. The testing shall be done by a trained operator in the presence of the engineer. The testing procedure and the evaluation of the profilogram shall be done in accordance with this specification and MoDOT Test Method T59. The profilogram and evaluation shall be furnished to the engineer not later than the end of the next day worked following placement of the pavement and within two days after corrective grinding.

**502.14.1.8** The engineer may also test the surface or re-evaluate the profilogram for comparison and assurance purposes. If these tests or re-evaluations indicate the contractor-furnished profilograms are not accurate within 3.0 inches per mile (45 mm/km), the engineer may test the entire project length. If the entire project length is tested, the contractor will be charged for this work at the rate of \$500.00 per lane mile (\$310.00 per lane kilometer). Furnishing inaccurate test results may result in disapproval of the operator.

**502.14.1.9** The profilogram line drawn by the profilograph will be referred to as the profile trace in these specifications.

**502.14.1.10** A profile index shall be calculated from the profilogram for pavements 50 feet (15 m) or more in length. The profile index is calculated by summing the vertical deviations of the profile trace above or below the dashed reference line on the transparent scale. The units of this measure are inches per mile (mm/km).

**502.14.1.11** Bumps shall be separately identified. These appear as high points on the profile trace and correspond to high points or bumps on the pavement surface. They are identified by locating vertical deviations greater than 0.40 inch (10 mm) for a 25-foot (7.622 m) span, as indicated on the profile trace.

**502.14.2 Straightedging.** As soon as practicable, the engineer will straightedge all segments of the paved surface not profilographed, including shoulder areas between rumble strips, and mark any variations exceeding 1/8 inch in 10 feet (3 mm in 3 m). Areas more than 1/8 inch (3 mm) high shall be removed by an approved device as listed in [Sec 502.14.6.3](#).

**502.14.3 Equipment.** The profilograph shall be a California type as approved by the engineer. The equipment furnished shall be supported on multiple wheels having no common axle. The wheels shall be arranged in a staggered pattern such that no two wheels cross the same bump at the same time. The pavement profile is recorded from the vertical movement of a sensing wheel attached to the frame at midpoint and is in reference to the mean elevation of the 12 points of contact with the road surface established by the support wheels. The profilogram is recorded with a scale of one inch equals one inch (1 mm equals 1 mm) vertically and one inch equals 25 feet (1 mm equals 300 mm) longitudinally.

**502.14.4 Calibration.** All profilographs used shall be calibrated at least annually on a test section established by MoDOT. The contractor's calibration profile index shall not vary more than 2.0 inches per mile (30 mm/km) from a standard profile index produced by a MoDOT profilograph.

**502.14.4.1** Longitudinal calibration consists of pushing the profilograph over a pre-measured test distance and determining the scale factor by dividing the premeasured test distance by the length of the paper in inches (millimeters). This factor shall be 25 (300), one inch equals 25 feet (25 mm equals 7.622 m). If not, the machine shall be adjusted until the scale factor is 25 (300) plus or minus 0.2 percent.

**502.14.4.2** Vertical calibration consists of sliding a pre-measured calibration block, measured to the nearest 0.01 inch (0.25 mm), under the sensing wheel while the profilograph is stationary. The measurement of the vertical trace line from the base line to the peak and return shall be the same as the calibration block. The trace line must return to the base line. No tolerance will be allowed.

**502.14.4.3** A profilograph equipped with automatic profile trace reduction capabilities shall be checked by comparing the machine's results with the results obtained by the engineer. This shall be done for the profile trace obtained on the MoDOT test section. The results and the profilogram shall be submitted to the engineer. The results of the comparison may not differ by more than 2.0 inches per mile (30 mm/km).

**502.14.4.4** The contractor shall furnish certification that the 25-foot (7.622-meter) profilograph test and evaluation was conducted by an operator trained in the use of profilograph equipment and with sufficient experience to demonstrate the operator's competence.

**502.14.5 Test Procedures.** Smoothness will be tested by measurement with a profilograph. This device produces a profilogram of the surface tested.

**502.14.5.1** All objects and foreign material on the pavement surface, including protective covers, if used, shall be removed by the contractor prior to testing and, if appropriate, protective covers shall be properly replaced by the contractor after testing.

**502.14.5.2** The profilograph shall be propelled at walking speed in the paths indicated in [Sec 502.14.1.1](#) for each section of pavement. Propulsion may be provided by personnel pushing manually or by a suitable propulsion unit.

**502.14.5.3** A location indicator for lateral placement is mandatory. More than one person may be required to hold the back end of the profilograph exactly in the required path on horizontal curves except as stated in [Sec 502.14.1\(b\)](#).

**502.14.5.4** Walking speed shall be decreased if excessive spikes are encountered.

**502.14.5.5** The sensing wheel shall be lifted, rotated to take slack out of the linkage, and lowered to the pavement surface at the starting point prior to testing.

**502.14.5.6** The actual stationing shall be noted on the profilogram at least every 200 feet (50 m). Station referencing is used to accurately locate deviations greater than 0.40 inch (10 mm).

**502.14.5.7** Both ends of the profilogram shall be labeled with the stationing, lane designation, position on the pavement and the direction the pavement was placed. A report form furnished by the engineer shall be completed and placed with the profilogram.

**502.14.5.8** When operating the profilograph, all wheels shall be on the new pavement for which the contractor is responsible.

**502.14.6 Surface Corrections.** Bump correction or smoothness correction or both may be required.

**502.14.6.1** If an average profile index of 45.0 inches per mile (711 mm/km) for pavements having a final posted speed greater than 45 mph (70 km/h), or 65.0 inches per mile (1026 mm/km) for pavements having a final posted speed of 45 mph (70 km/h) or less, is exceeded in any daily paving operation, the paving operation will be suspended and will not be allowed to resume until corrective action approved by the engineer is taken by the contractor.

**502.14.6.2** All bumps greater than 0.40 inch (10 mm) in height over a 25-foot (7.622-meter) span, as indicated on the profile trace, shall be corrected. The corrected bumps will be considered satisfactory when measurements by the profilograph show that the bumps are 0.40 inch (10 mm) or less in height over a 25-foot (7.622-meter) span.

**502.14.6.3** Corrective action to improve the average profile index shall be accomplished by longitudinally diamond grinding or by use of an approved device designed for that purpose. The device shall be designed to improve the profile of the riding surface. The use of a bush hammer or other impact device will not be permitted.

**502.14.6.4** After removing all individual deviations greater than 0.40 inch (10 mm) in height, additional correction shall be performed if necessary to reduce the average profile index to

30.0 inches (474 mm) or less per mile (kilometer) for pavements having a final posted speed greater than 45 mph (70 km/h), or 45.0 inches (711 mm) or less per mile (kilometer) for pavements having a final posted speed of 45 mph (70 km/h) or less. All corrective work shall be completed prior to determination of pavement thickness. On pavement segments where corrections are necessary, additional profiles shall be made to verify that the corrections have produced an average profile index within the limits noted above.

**502.14.6.5** If the initial average profile index of any segment is less than 30.1 inches per mile (475 mm/km) for pavements having a final posted speed greater than 45 mph (70 km/h), or less than 45.1 inches per mile (712 mm/km) for pavements having a final posted speed of 45 mph (70 km/h) or less, only the areas with deviations greater than 0.40 inch (10 mm) in height shall be retested for correction verification.

**502.14.6.6** The final surface of the corrected concrete pavement shall be such that the texture is comparable to adjacent sections that do not require correcting. Satisfactory longitudinal grinding is acceptable as the final surface of the corrected pavements.

**502.15 Opening to Traffic.** The concrete pavement shall not be opened for light traffic until the concrete is at least 72 hours old and has attained a minimum compressive strength of 3000 pounds per square inch (21 MPa). The pavement shall not be opened to all types of traffic until the concrete is at least 72 hours old and has attained a minimum compressive strength of 3500 pounds per square inch (24 MPa). If high early strength concrete is used, the pavement may be opened to all types of traffic when the concrete has attained a minimum compressive strength of 3500 pounds per square inch (24 MPa). Compressive strength will be determined by tests made in accordance with MoDOT methods. Pavement shall be cleaned prior to opening to traffic.

**502.16 Slip-Form Construction.** At the option of the contractor, pavement may be constructed by the use of sliding form methods. All applicable provisions of [Sec 502](#) shall be followed. In addition, the following provisions shall apply.

**502.16.1 Subgrade and Base.** If an aggregate base course is specified for the pavement, it shall be constructed in accordance with the requirements of [Sec 304](#) and the slip-form paver shall operate on the aggregate base. After the grade or base has been placed and compacted to the specified density, the areas which will support the paving machine and the area upon which the pavement is to be placed shall be cut to the proper elevation by means of an approved machine.

**502.16.2 Placing Concrete.** A self-propelled concrete spreader equipped with a power-driven device for spreading the concrete uniformly across the subgrade transversely shall be used to place the concrete. The spreader shall also be equipped with an adjustable strike-off blade capable of striking off the surface of the concrete in the longitudinal direction of the pavement at any required elevation. For isolated pavement lanes over 200 feet (60 m) long but less than 2000 feet (600 m) long, a mechanical spreader will not be required.

**502.16.3 Consolidating and Finishing Equipment.** The concrete shall be consolidated and finished by a slip-form paver designed to spread, consolidate and shape the concrete in one complete pass of the machine in such a manner to provide a smooth, dense and homogeneous pavement in conformance with the plans and specifications. Hand finishing is discouraged. The slip-form paver shall be fully energized, self-propelled and crawler mounted. It shall be of sufficient weight (mass) and power to construct the maximum specified concrete paving lane width as shown on the plans at an adequate forward speed, and without transverse, longitudinal or vertical instability or displacement. The slip-form paver shall produce a surface reasonably free of surface voids and tears. The machine shall satisfactorily vibrate the

concrete for the full width and depth of the pavement being placed. No apparent slumping of the concrete shall occur 6 inches (150 mm) or more in from the pavement edge. All operations of mixing, delivering and spreading concrete shall be so coordinated as to provide uniform progress with stopping and starting of the paver held to a minimum. If it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately.

**502.16.4 Forms.** Forms shall be used where necessary to produce a pavement of plan section and shall incorporate a keyway where required.

**502.16.4.1** Longitudinal tongue and groove joints of the specified type and size shall be constructed at locations shown on the plans or approved by the engineer. The groove side of the joint shall be slip-formed or formed with approved metal forms that will produce a keyway conforming to plan location and dimensions. The form shall remain in place for sufficient time to prevent slump. Metal forms may be left in place if approved by the engineer. The tongue side of the joint may be constructed without forms provided the plan section of the pavement and joint is maintained.

**502.16.4.2** Where tie bars are required at longitudinal construction joints, a tongue and groove type joint shall be constructed and the tie bars shall be installed in the groove side of the joint. The bars shall be positioned before pavement consolidation.

**502.16.5 Protection Against Rain.** To protect against the effects of rain, the contractor shall have on location at all times material for the protection of the edges and surface of the unhardened concrete. It is the contractor's responsibility to protect the pavement from damage due to rain. Failure to properly protect unhardened concrete may constitute cause for the removal and replacement of defective pavement at the contractor's expense.

**502.17 Tolerance in Pavement Thickness.** It is the intent of these specifications that pavement shall be constructed strictly in accordance with the thickness shown on the plans. The thickness of the pavement will be measured, and where any pavement is found deficient in thickness, deductions for or removal of thin pavement will be made in accordance to [Sec 502.19](#).

**502.17.1** Metal plates will be placed on the subgrade at points selected by the engineer in areas where the planer has cut or leveled off the subgrade or at any points where conditions are conducive to deficient pavement thickness. When the surface of the pavement has been finished to final grade, the engineer will, for informational purposes, check the thickness of the completed pavement by measuring the distance from the surface of the pavement to the metal plates by use of a calibrated rod. The surface of the pavement shall be satisfactorily restored by the contractor after thickness measurements have been made. The contractor shall, if necessary, furnish a bridge to facilitate the taking of the measurements. The engineer reserves the right to core drill the finished pavement to determine the thickness of the pavement. Cores may be drilled at the same locations as rod measurements or at any other locations. The contractor may require check cores to verify thicknesses determined by the engineer, and all costs of check core drilling shall be borne by the contractor. If the check cores requested by the contractor indicate that the engineer's measurement would have erroneously resulted in deductions for, or removal of, thin pavement, the cost of drilling the check cores will not be charged to the contractor.

**502.17.2** The thickness of the pavement will be determined by average caliper measurement of cores in accordance with the procedure established by the Commission.

**502.17.3** For the purpose of determining the constructed thickness of the pavement, cores will be taken at random intervals in each traffic lane at the rate of 1 core per 1000 feet (300 m) or increment thereof. In addition, cores will be taken at all locations where thickness measurements taken during construction indicate a thickness deficiency sufficient to justify a deduction from the contract unit price, or at any other locations as may be determined by the engineer. If the measurement of any core is deficient in excess of 2/10 inch (5 mm) from the plan thickness, additional cores will be taken at 30-foot (10 m) intervals parallel to centerline ahead and back of the affected location until the extent of the deficiency has been determined.

**502.17.4** It will be assumed that each core is representative of the pavement thickness for a distance extending one-half the distance to the next core, measured along centerline, or in the case of a beginning or ending core, the distance will extend to the end of the pavement section.

**502.17.5** The drilling of cores in irregular areas, or on projects involving less than 2500 square yards (2000 m<sup>2</sup>) of concrete pavement, may be waived by the engineer. In this case the designed thickness will be considered as the measured thickness.

**502.17.6** Cores may be waived by the engineer for full depth concrete shoulders if satisfactory rod measurements are obtained. If coring of full depth concrete shoulders is performed, any treatment for deficiencies will be the same as for pavement.

**502.18 Method of Measurement.** Pavement areas will be computed to the nearest 1/10 square yard (0.1 m<sup>2</sup>). Final measurement of the completed pavement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**502.19 Basis of Payment.**

**502.19.1** Pavement thickness determination will be made after all smoothness correction has been completed. If any core measurement of thickness is deficient, the contractor shall have the option of removing and replacing the pavement at the contractor's expense or of leaving the pavement in place and receiving the following deductions in payment.

Deficiency in Thickness	Deductions, Percent of Contract Unit Price
0 to 2/10 inch (5 mm)	None
Over 2/10 inch (5 mm) and not over 4/10 inch (10 mm)	15
Over 4/10 inch (10 mm) and not over 6/10 inch (15 mm)	60
Over 6/10 inch (15 mm)	100

The above deductions will be applied to a section of pavement 30 feet (9 m) long and extending from the edge of the pavement to a longitudinal joint or between longitudinal joints in that section of pavement in which the deficient measurement was found. Deductions for deficient thickness or damaged pavement may be entered on any estimate after the information becomes available.

**502.19.2** If pavement which is deficient in thickness in excess of 6/10 inch (15 mm) may, in the judgment of the engineer, seriously impair traffic service of the pavement, the contractor will be required to remove the pavement and to replace it with one of a satisfactory quality and thickness which, when accepted, will be included in the pay quantity. No payment will be made for any costs incurred in the removal of the pavement deficient in thickness. If, in the judgment of the engineer, there is no probability of immediate failure, the engineer may allow



the contractor the choice of leaving the deficient pavement in place and receiving no payment or of removing and replacing the pavement as provided herein.

**502.19.3** In removing pavement, it shall be removed from the edge to a longitudinal joint, or between longitudinal joints, and on each side of the deficient measurement until no portion of the exposed cross sections is more than 2/10 inch (5 mm) deficient, except that there shall not be less than 15 linear feet (4.5 m) of pavement removed. If there remains less than 15 feet (4.5 m) of acceptable pavement between the section that has been removed and a transverse contraction, expansion or construction joint, the contractor shall remove the pavement to the joint.

**502.19.4** For marred surface areas or slightly damaged concrete that remains in the completed pavement, a minimum deduction of 20 percent of the contract unit price will be made for the areas affected. The deduction will be applied to a section of pavement extending from edge of the pavement to a longitudinal joint or between longitudinal joints in that section of pavement affected. If the length of the section affected is less than 10 feet (3 m), the deduction will be computed for 10 feet (3 m). Areas corrected for smoothness will not be considered marred surfaces.

**502.19.5** Payment for smoothness shall be based on either Table I or Table II. Table I shall be used for pavements having a final posted speed greater than 45 mph (70 km/h). Table II shall be used for pavements having a final posted speed of 45 mph (70 km/h) or less and for pavements with no posted speed limits. Constant width acceleration and deceleration lanes shall be considered as mainline pavements.

Final Profile Index, Inches Per Mile (mm/km)		Percent of Contract Price
Table I	Table II	
10.0 (158) or less		107
10.1 - 15.0 (159 - 237)	15.0 (237) or less	105
15.1 - 18.0 (238 - 284)	15.1 - 25.0 (238 - 395)	103
18.1 - 30.0 (285 - 474)	25.1 - 45.0 (396 - 711)	100
30.1 - 45.0 (475 - 711)	45.1 - 65.0 (712 - 1026)	95*
45.1 (712) or greater	65.1 (1027) or greater	93*

\*Correction required.

**502.19.5.1** Smoothness incentive will be paid per section based on the profile index before bump correction. Within a section qualifying for incentive pay, any segment having a profile index requiring a reduction in contract price will not be included in incentive payment for that section.

**502.19.5.2** Segments with a profile index of 30.1 (475) or greater (Table I), or 45.1 (712) or greater (Table II), after bump correction, shall be corrected as specified in [Sec 502.14.6](#) until the profile index is 30.0 (474) or less (Table I), or 45.0 (711) or less (Table II), or at the contractor's option, the segment may be removed and replaced with no additional payment. Under Table I, those segments with a profile index of greater than 30.0 (474) and less than 45.1 (712) after bump correction will receive 100 percent of contract price when reduced to 30.0 (474) or less, and those segments with a profile index of 45.1 (712) or greater before bump correction will receive 93 percent when reduced to 30.0 (474) or less. Under Table II, those segments with a profile index of greater than 45.0 (711) and less than 65.1 (1027) after bump correction will receive 100 percent of contract price when reduced to 45.0 (711) or less,

and those segments with a profile index of 65.1 (1027) or greater before bump correction will receive 93 percent when reduced to 45.0 (711) or less.

**502.19.5.3** On sections where corrections are made, the pavement will be tested by the contractor to verify that corrections have produced a profile index of 30.0 (474) or less (Table I), or 45.0 (711) or less (Table II).

**502.19.5.4** The contractor will not be allowed to make corrective grinding to increase the percent of pay when the final profile index is 30.0 (474) or less (Table I), or 45.0 (711) or less (Table II).

**502.19.6** If the profile index, after bump correction, is 30.1 (475) or greater (Table I), or 45.1 (712) or greater (Table II), and the contractor elects to remove and replace the segment, the contractor will be paid the percent of contract price that corresponds to the replaced segment's profile index as specified above.

**502.19.7** The contract unit price for portland cement concrete pavement will be considered as full compensation for all material, including reinforcement, dowels, dowel supports, tie bars and any other items entering into the construction of the traveled way pavement or portland cement concrete shoulders, and for the cost of smoothness testing. No additional compensation will be allowed for any excess thickness.

**502.19.8** The accepted quantities of portland cement concrete pavement will be paid for at the contract unit price with proper allowance made for any deductions for deficiency in thickness, smoothness or marred surface.

**502.19.9** When paving widths are greater than the travel lane widths, profiling and payment for profiling will apply to the traffic lane design driving width only, normally 12 feet (3.6 m). Random lane coring for thickness or required lane replacement will include the full paved lane width to the longitudinal joints or edge of shoulder, whichever is first.

## SECTION 503

### BRIDGE APPROACH SLAB

**503.1 Description.** This work shall consist of a reinforced concrete bridge approach slab constructed on a prepared subgrade in accordance with these specifications, and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer.

**503.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete Structures	<a href="#">1036.1</a>
Concrete Curing Material	<a href="#">1055</a>
Material for Joints	<a href="#">1057</a>
Polyethylene Sheeting	<a href="#">1058</a>

All material, proportioning, air-entraining, mixing, slump and transporting of portland cement concrete shall be in accordance with [Sec 501](#). Approach slabs shall be constructed of Pavement concrete.

**503.3 Construction Requirements.** Bridge approach slabs shall be constructed in accordance with the applicable requirements of [Secs 703](#) and [706](#) and shall attain a compressive strength of 4000 pounds per square inch (28 MPa) prior to opening to traffic.

**503.3.1 Voids Under Completed Approach Slabs.** Prior to acceptance of the work, all underseal access holes shall be opened by the contractor to permit investigation by the engineer. Any voids or cavities found shall be filled by the contractor with a soil-cement slurry pumped under pressure. The slurry shall consist of a sandy loam, approved by the engineer, mixed with four parts soil to one part cement, by volume, with only sufficient water to produce a mixture that will flow from one hole to another while being pumped. Care shall be taken during pumping operations to avoid raising the approach slab. At completion of the investigation or underseal pumping, the holes shall be filled with sand to within one inch (25 mm) of the top and the remainder filled with joint sealing material.

**503.4 Method of Measurement.** The area of the approach slab will be measured and computed to the nearest square yard (square meter). This area will be measured transversely from out to out and longitudinally from bridge fill face to centerline of sleeper slab. Final measurement of the completed bridge approach slab will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**503.5 Basis of Payment.** The amount of completed and accepted work as shown on the bridge plans, measured as provided above, will be paid for at the contract unit price per square yard (square meter) and shall include full compensation for all material, labor, equipment, tools and incidentals necessary to complete the bridge approach slab.

**503.5.1** No direct payment will be made for the reinforcing steel for bridge approach slabs. Also, no direct payment will be made for investigating void conditions under the completed slab or for filling any voids found.

## SECTION 504

### CONCRETE APPROACH PAVEMENT

**504.1 Description.** This work shall consist of a reinforced concrete approach pavement constructed on a prepared subgrade in accordance with these specifications, and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer.

**504.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete Structures	<a href="#">1036.2</a>
Concrete Curing Material	<a href="#">1055</a>
Material for Joints	<a href="#">1057.1</a>

All material, proportioning, air-entraining, mixing, slump and transporting of portland cement concrete shall be in accordance with [Sec 501](#). Approach pavement shall be constructed of pavement concrete.

**504.3 Construction Requirements.** Concrete approach pavement and tied shoulders shall be constructed in accordance with the applicable requirements of [Sec 502](#). Reinforcement shall be supported and held securely in place by approved metal or plastic bar supports.

**504.4 Method of Measurement.** Concrete approach pavement areas including tied shoulders will be computed to the nearest 1/10 square yard (0.1 m<sup>2</sup>). Final measurement of the completed concrete approach pavement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**504.5 Basis of Payment.** The accepted quantity of concrete approach pavement will be paid for at the contract unit price.

**504.5.1** No direct payment will be made for the reinforcing steel.

## SECTION 505

### BRIDGE DECK CONCRETE WEARING SURFACE

#### SECTION 505.10 LOW SLUMP CONCRETE

**505.10.1 Description.** This work shall consist of a wearing surface of low slump, dense concrete constructed on a prepared surface in accordance with these specifications, and in conformity with lines, grades, thickness and typical cross sections shown on the plans or established by the engineer.

**505.10.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Type I or II Cement	<a href="#">1019</a>
Air-Entraining Admixture	<a href="#">1054</a>
Water Reducing Admixture	<a href="#">1054</a>
Burlap	<a href="#">1055</a>
Polyethylene Sheeting	<a href="#">1058</a>
Water	<a href="#">1070</a>

**505.10.2.1** Coarse aggregate shall be an approved crushed limestone, crushed quartzite, flint chat from the Joplin area, or porphyry meeting the requirements of [Sec 1005.1](#), Gradation E, except the percentage of deleterious substances shall not exceed the following values, and the sum of percentages of all deleterious substances shall not exceed one percent.

Item	Percent by Weight (Mass)
Deleterious Rock	1.0
Shale and Pyrite	0.2
Chert in Limestone	0.5
Other Foreign Material	0.1

**505.10.2.2** Fine aggregate shall comply with [Sec 1005.2](#) and shall be Class A sand as specified in [Sec 501](#).

**505.10.2.3** Pozzolanic material or portland pozzolan cements shall not be used.

**505.10.2.3** Grout shall be a mixture of equal parts, by weight (mass), of portland cement and fine aggregate, mixed with sufficient water to form a stiff slurry. The consistency of this slurry shall be such that it can be applied with a stiff brush or broom to the concrete in a thin, even coating that will not run or puddle in low spots. For sealing vertical joints, this grout shall be thinned to paint consistency.

#### **505.10.3 Concrete Mixture.**

**505.10.3.1** The proportions of cement, fine aggregate and coarse aggregate will be designated by the engineer and shall meet the following properties:

Air Content, percent	5.5 ± 1.5
Slump, inches (mm)	1/2 ± 1/2 (13 ± 13)
Percent Fine Aggregate as percent of total aggregate by absolute volume	50
Cement Content, sacks/cubic yard (kg/m <sup>3</sup> )	8.70 to 8.80 (485 to 490)

**505.10.3.2** The cement content and percent fine aggregate shall not be changed. If total mixing water, including free water in aggregate and liquid admixtures, varies sufficiently from design mixing water to cause a change in batch volume of more than two percent, the engineer will redesign the mixture.

**505.10.3.3** A Type A water reducing admixture for improving workability is required.

**505.10.3.4** During placement, the mixture shall be compacted to not less than 98 percent of the standard density.

#### **505.10.4 Testing.**

**505.10.4.1** Slump will be determined as specified in AASHTO T 119. The sample for test of slump shall be taken at the point of placement in the structure.

**505.10.4.2** Air content will be determined by the pressure method as specified in AASHTO T 152.

**505.10.4.3** When required, standard density, unit weight (mass), will be determined in accordance with AASHTO T 121. Standard density will be determined for at least each 2 hours of concrete production or any time significant fluctuations occur within the range of air content or slump.

**505.10.4.4** Compressive strength will be determined from standard 6 x 12 inch (152.2 x 304.8 mm) cylinders prepared and tested in accordance with MoDOT methods. One set consisting of 2 cylinders will be made for 28 days compressive strength from each day's production. Cylinders made for determining when to allow traffic will be made at a frequency determined by the engineer and shall be cured in the near vicinity and in the same manner as the bridge deck.

**505.10.4.5** Concrete taken as a sample for testing slump and air content shall be wasted and shall not be placed in the deck. If air content or slump test results do not comply with specification requirements, any concrete represented by those tests and any concrete in the mixer chute shall be wasted, and the necessary adjustments made in the mix design or proportioning devices.

**505.10.4.6** When required, in-place density of plastic concrete will be determined in accordance with MoDOT Test Method T36. In-place density will be determined at the approximate rate of one test per 20 linear feet (6 m) per 12-foot (3.6 m) lane. A nuclear gauge correction factor will be determined at least once for each day of concrete production. Work bridges spanning the plastic concrete shall be provided by the contractor to permit making nuclear density tests.

### **505.10.5 Mixing.**

**505.10.5.1** Concrete shall be mixed at the bridge site by weight (mass) or volume in accordance with [Sec 501](#). The concrete mixer shall be approved by the engineer and shall be a stationary mixer of the rotating paddle type or a continuous mixer used in conjunction with volumetric proportioning.

**505.10.5.2** Mixing time for rotating paddle type mixers shall not be less than 60 seconds after all ingredients have been added. All batches shall be mixed approximately the same length of time. Material for a batch of concrete shall not be placed in the mixing drum until the material for the previous batch has been discharged.

### **505.10.6 Surface Preparation.**

**505.10.6.1** On new concrete decks, the surface shall be given a very rough texture while still plastic by use of a wire comb or other approved texturing device which will produce a bondable surface acceptable to the engineer.

**505.10.6.2** On old existing concrete, the surface shall be uniformly scarified to an approximate depth of 1/4 inch (6 mm). Excessive tearing of the surface shall require adjustment of the scarifier drum or replacement of the machine. Over areas of half-sole repair and full depth repair, the 1/4 inch (6 mm) removal may be coincidental with operations for repair removal.

**505.10.6.2.1** Scarifying equipment shall be a power operated, mechanical scarifier capable of uniformly scarifying or removing the not less than 1/4 inch (6 mm) of existing concrete surface or depths as required. The scarifier shall not produce a polished or slick surface.

**505.10.6.2.2** In areas which cannot be machine scarified, concrete shall be scarified approximately 1/4 inch (6 mm) deep by chipping and by use of hand tools. Any epoxy patches encountered shall be completely removed to sound, natural concrete. Surfaces of concrete patches placed in the deck after machine scarifying shall remain rough or be bush-hammered before placing the overlay.

**505.10.6.3** The textured or scarified deck shall be sandblasted followed by an air blast. The sandblast shall be of sufficient duration to remove all dirt, oil and other foreign material, as well as any unsound concrete or laitance from the surface and edges against which new concrete is to be placed. The compressor shall be equipped with a filter to prevent oil in the air supply. That portion of the curb and previously placed overlays against which new concrete is to be placed shall be sandblasted. If any loose or foreign material is detected on the concrete surface prior to placement of the overlay, it shall be removed by sand or air blasting and retextured if necessary where penetration of foreign material is evident. No contamination of the retextured or scarified concrete surface, of any degree, will be allowed.

**505.10.6.4** To assure that the thickness of the concrete overlay above the prepared surface will be as specified on the plans, the clearance shall be checked in the following manner before concrete is placed. A filler block having a thickness 1/8 inch (3 mm) less than the overlay thickness shall be attached to the bottom of the screed. With screed guides in place, the screed shall be passed over the area to be concreted. Where the intended clearance does not allow use of this method, a stringline or other means shall be used, subject to approval of the engineer. All old concrete which does not have sufficient clearance shall be removed. Hand tools shall be used to remove final particles of concrete or to achieve the required depth.

### **505.10.7 Finishing Equipment.**



**505.10.7.1 Finish Machine.** The finishing machine shall be designed for striking off and finishing low slump concrete overlay. The machine shall be mechanically powered to operate forward and reverse in a smooth manner, under positive control of the operator. The basic machine shall be of a width to finish a basic 12 foot (3.6 m) width of overlay and be adjustable for wider placements. It shall be so designed that screeds may be extended with bolted units to match the extension of the basic unit. The drive wheels shall be of the type that may be replaced with solid rubber wheels to permit travel upon previously completed lanes of overlay when striking off the abutting lanes.

**505.10.7.2 Screeds.**

**505.10.7.2.1** The machine shall be equipped with two oscillating transverse screeds. They shall oscillate in a straight line. A swinging pendulum stroke will not be permitted. The front screed shall vibrate uniformly for its full length. The vibrators shall be placed so the screed vibrates efficiently and the frequency of the vibrators shall be controlled by the operator from the console so as to achieve the required density.

**505.10.7.2.2** The screeds shall be held positive to the machine with rollers and unless otherwise approved by the engineer, be equipped with screed guides so as to control the profile grade of the finished overlay. The screed stroke shall be synchronized to speeds not to exceed 50 strokes per minute with infinite variable control from the console. The screeds shall be hydraulically controlled for vertical lift when the machine is reversed for travel and controlled for downward direction to the finishing position to permit feathering of the screeds to any previously finished surface.

**505.10.7.2.3** The bottom face of the screeds shall be at least 5 inches (125 mm) in width, with an effective pressure to produce not less than 75 pounds per square foot (366 kg/m<sup>2</sup>). The bottom face of the screeds shall have a turned up leading edge to prevent tearing of the screeded surface, and be adjustable for tilt and crown. The screed lengths shall be such to produce positive strike off and density of the concrete for at least 6 inches (150 mm) beyond the line where the saw cut for the longitudinal joint is to be made, and to within 1 inch (25 mm) of the curb reinforcing steel or face of any curb barrier already in place.

**505.10.7.3 Traveling Strike-Off.** The machine shall be equipped with a mechanically powered adjustable auger that is positioned in front of the lead screed. The strike-off shall travel back and forth for the full width to be screeded and be properly designed to meter the concrete to the screeds.

**505.10.7.4 Support Rails.** Heavy duty support rails shall be used to support the finishing machine. The rail supports shall be adjustable and the rail shall not deflect between adjustable supports more than 1/32 inch (0.8 mm). They shall be placed outside the area and parallel to axis of the area to be concreted. Support rails shall extend a sufficient distance beyond the end of the deck to allow the finishing machine to be completely removed from the deck surface so that hand finishing may proceed without interruption. The rails shall be set to produce the final profile grade of the surface of the overlay. A holddown device shot into the concrete will not be permitted unless the concrete is to be subsequently resurfaced. The method of anchoring the support rails must be submitted to the engineer for approval.

#### **505.10.8 Placing and Finishing Concrete.**

**505.10.8.1** The concrete surface at the time of applying grout shall be dry to allow some absorption of the grout. The concrete surface shall be allowed to dry after a rain. The engineer will determine when placement may begin.

**505.10.8.2** A lateral support for the concrete such as 2 x 4-inch (50 x 100 mm) lumber attached to the deck shall be required at least 6 inches (150 mm) beyond the line where the saw cut for the longitudinal joint is to be made.

**505.10.8.3** At transverse and longitudinal joints, the surface course previously placed shall be sawn to a straight vertical edge before the adjacent course is placed.

**505.10.8.4** In order to avoid locating the longitudinal construction joints in a wheelpath, they shall be placed between the designated traffic lanes. The location of the longitudinal joints shall be subject to the approval of the engineer.

**505.10.8.5** Transverse joints in the overlay will be permitted subject to the approval of the engineer. These joints shall be located a minimum of 10 feet (3 m) from the centerline of bent.

**505.10.8.6** The contractor shall take every reasonable precaution to secure a smooth riding bridge deck. Prior to placement operations, the contractor shall review with the engineer, equipment, procedures, personnel and previous results as well as inspection procedures to assure coordination. The contractor shall take every reasonable precaution to ensure that concrete can be produced and placed within the specified limits, continuously and with uniformity.

**505.10.8.7** The areas of half-sole and full depth repair shall have individual concrete placement up to 1/4 inch (6 mm) of the top surface of the original deck. These individual placements shall remain rough and shall be completed before the overlay course is started. Areas of half-sole, full depth repair and all other patched areas shall be surface dried, sandblasted and cleaned prior to the application of grout for the placement of low slump concrete wearing surface.

**505.10.8.8** A thin coat of bonding grout shall be scrubbed into the dry prepared surface, including that portion of curbs against which new concrete is to be placed and the vertical face of previously placed overlay, immediately before placing concrete. Care shall be exercised to ensure even coating and that no excess grout is permitted to collect in pockets. The rate of applying grout shall be limited so that grout does not become dry before it is covered with new concrete.

**505.10.8.9** If grout is allowed to dry out, a header shall be placed, and no further concreting shall be done until the old grout has been removed and the surface again sandblasted.

**505.10.8.10** The wheels of rubber wheeled vehicles or transport containers for the concrete shall not be allowed to contact any portion of the concrete surface prior to placement of the concrete. Protection shall be provided for the concrete surface by means of plywood, mats or other suitable material placed on the surface. Any loose or foreign material or rubber marks accidentally deposited on the surface shall be removed by the contractor prior to grouting.

**505.10.8.11** Placement of the concrete shall be a continuous operation throughout the pour. Only the minimum amount of concrete necessary for proper placement will be allowed in front of the screeds. If the concrete paver is stopped for any reason, all plastic concrete in front of

the paver is to be covered with wet burlap. The concrete shall be poured and finished at a minimum of 2.5 cubic yards (2 m<sup>3</sup>) per hour for a 12-foot (3.6 m) wide pour, however, if the contractor elects to pour a wider section, the rate of pour shall be increased proportionately. The finishing machine shall be so designed that, when concrete is being mixed and placed at the specified minimum rate, under normal operations, the elapsed time between depositing the concrete on the deck and final screeding shall not exceed 10 minutes.

**505.10.8.12** The new concrete shall be manipulated and mechanically struck-off slightly above final grade. It shall then be mechanically consolidated by the finishing machine to the required density and screeded to final grade. If concrete is added to the overlay behind the finishing machine, the area shall be mechanically consolidated again by the finishing machine.

**505.10.8.13** After finishing, the contractor shall check the surface with a lightweight 10 foot (3 m) straightedge. Causes for irregularities exceeding 1/8 inch (3 mm) shall be eliminated, and corrections shall be made.

**505.10.8.14** The roadway surface finish shall be in accordance with [Sec 703.3.14.5](#). The texture shall not extend into the areas within approximately 12 inches (300 mm) of curbs.

**505.10.8.15** After texturing the concrete surface but before covering with wet burlap, all vertical joints with the adjacent concrete shall be sealed by painting with thinned grout.

**505.10.8.16** After the joint painting is completed, the freshly placed lane and joint shall be promptly covered with a single layer of clean, wet burlap. Care shall be exercised to ensure that the wet burlap is well drained and that it is placed as soon as the surface will support it without deformation.

**505.10.8.17** The wet burlap shall be applied within 30 minutes after the concrete has been placed on the deck, except when the surface will be excessively marred by so doing, as determined by the engineer. If it is necessary to refinish the concrete because of failure to meet density requirements, this time will be extended 15 minutes. Failure to apply wet burlap within the required time shall be cause for rejecting the work so affected. Surface concrete in the rejected area shall be removed and replaced by the contractor at the contractor's expense.

**505.10.8.18** The surface shall receive a wet burlap cure of at least 72 hours. For the first 24 hours, the burlap shall be kept continuously wet by means of an automatic sprinkling or wetting system. After 24 hours, the contractor may cover the wet burlap with a layer of 4-mil (0.10 mm) polyethylene film for a minimum of 48 hours in lieu of using a sprinkling or wetting system.

**505.10.8.19** After placement and cure of the low slump concrete, the finished deck will be tested to detect unbonded areas and the contractor required to cut out and replace any unbonded areas at the contractor's expense. Repair shall be performed as specified in these specifications.

**505.10.8.20** As soon as curing has been completed, the riding surface will be thoroughly straightedged by the engineer and all variations exceeding 1/8 inch (3 mm) in 10 feet (3 m) will be plainly marked. Areas more than 1/8 inch (3 mm) high shall be removed by an approved device consisting of multiple cutting edges leaving a grooved surface finish comparable to that produced by the texturing device. The use of a bush hammer or other impact device will not be permitted.

**505.10.8.21** The surface of low slump concrete shall be surface sealed in accordance with [Sec 703.3.18](#), and payment for furnishing and placing shall be included in the price bid for other items.

**505.10.9 Limitations of Operations.**

**505.10.9.1** No vehicle traffic shall be permitted on the low slump concrete surface for 72 hours, and in no case until 3000 psi (21 MPa) compressive strength is attained. At temperatures below 55 F (13 C), a longer curing period may be necessary to attain this strength.

**505.10.9.2** No low slump concrete shall be placed at ambient temperatures below 45 F (7 C) or above 85 F (30 C). Concrete placement may begin when the air temperature and deck temperature is 45 F (7 C) and rising. Concrete shall not be exposed to freezing temperatures until a strength of 3000 psi (21 MPa) has been attained. Any concrete damaged by freezing shall be removed and replaced at the contractor's expense.

**505.10.9.3** When the weather forecast predicts temperatures of 85 F (30 C), or higher, the contractor shall schedule placing and finishing low slump concrete during hours in which the ambient temperature will be lower than 85 F (30 C). The mixed concrete when placed shall have a temperature no higher than 90 F (32 C).

**505.10.9.4** Concrete shall not be placed adjacent to a parallel surface course less than 72 hours old. However, this restriction does not apply to a continuation of placement in a lane or strip beyond a joint in the same lane or strip.

**505.10.9.5** Preparation of the area may be started in a lane or strip adjacent to newly placed surface the day following its placement. If this work is started before the end of the 72 hour curing period, the work will be restricted as follows:

- (a) Sawing or other operations shall interfere with the curing process for the minimum practical time only, and in the immediate work area only, and the curing shall be resumed promptly,

- (b) No power-driven tools heavier than a 15 pound (7 kg) chipping hammer shall be used,

- (c) Air compressors shall be operated on the deck only directly over the piers, and

- (d) No loads other than construction equipment shall be permitted on any portion of the bridge floor that has undergone preparation and prior to placement and curing of new concrete.

**505.10.10 Removal.** All material removed shall be disposed of by the contractor in a location meeting the approval of the engineer.

**505.10.11 Repair.**

**505.10.11.1** Unbonded areas will be marked by the engineer. The contractor shall then saw cut around the area and remove the affected area. All saw cuts shall be straight vertical lines and form square corners at all changes in direction. After removal of the concrete, the surface of the area to be repaired and vertical saw cuts shall be cleaned of all grout residue and loose or foreign material by sandblasting and then air blasting. The surface shall be comparable to the original concrete surface prior to the original overlay being placed. Grout shall be

scrubbed into the surface of the area to be repaired and the vertical saw cuts just prior to placing low slump concrete in the area. The grout and application requirements of the grout shall meet the requirements of the grout specifications for the specified wearing surface.

**505.10.11.2** The concrete used for repair shall meet the same requirements as the original mixture. It shall be vibrated with a surface or pan type vibrator to obtain compaction. Spud type vibrators shall not penetrate to contact with the original concrete. Surface finish and curing shall be in conformance with the specifications for the mixture used.

**505.10.12 Method of Measurement.**

**505.10.12.1** The area of concrete wearing surface will be measured and computed to the nearest square yard (square meter). This area will be measured longitudinally from end to end of bridge deck and transversely between roadway face of curbs, excluding from measurement the area of drains and expansion devices.

**505.10.12.2** Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**505.10.13 Basis of Payment.** Payment for the above described work including all material, equipment, labor and any other incidental work necessary to complete this item shall be considered as completely covered by the contract unit price per square yard (square meter) of concrete wearing surface.

**SECTION 505.20 LATEX MODIFIED CONCRETE**

**505.20.1 Description.** This work shall consist of a wearing surface of latex modified concrete constructed on a prepared surface in accordance with these specifications and in conformity with lines, grades, thickness and typical cross sections shown on the plans or established by the engineer.

**505.20.2 Material.** All material shall conform to [Sec 505.10](#), Division 1000, Materials Details, and specifically as follows:

Item	Section
Type I or II Cement	<a href="#">1019</a>
Latex Emulsion Admixture	<a href="#">1054</a>
Polyethylene-Burlap Sheeting	<a href="#">1055</a>
Polyethylene Sheeting	<a href="#">1058</a>
Water	<a href="#">1070</a>

**505.20.2.1** Aggregate shall meet the requirements of [Sec 505.10](#).

**505.20.2.2** Pozzoloanic material or portland pozzolan cements shall not be used.

**505.20.2.3** Latex admixture shall be kept in suitable enclosures which will protect it from freezing and from exposure to temperatures in excess of 85 F (30 C). Drums of latex admixture to be stored at the work site in direct sunlight shall be covered both top and sides with suitable insulating blanket material in order to maintain an enclosed temperature below 85 F (30 C).

### 505.20.3 Concrete Mixture.

**505.20.3.1** The proportions of cement, fine aggregate, coarse aggregate and latex emulsion admixture will be designated by the engineer and shall meet the following requirements:

Air Content, percent	0 to 6.5
Slump, inches (mm)	4 to 6 (100 to 150)
Percent Fine Aggregate as percent of total aggregate by absolute volume	50 to 55
Cement Content, sacks/cubic yard ( $\text{kg/m}^3$ ) min.	7.0 (390)
Latex Emulsion Admixture, gal./sack (L/kg)	3.5 (0.31)
Net Water-Cement Ratio, max., lbs. (kg) water/lbs. (kg) cement	0.40

**505.20.3.1.1** Mixing water added shall be adjusted to control the slump within the prescribed limits. Net water shall be considered the quantity of mixing water added plus the non-solid portion of the latex emulsion.

**505.20.3.2** Any change in mix design or proportions must be approved by the engineer.

**505.20.3.3** Anti-foam additives as recommended by the latex emulsion manufacturer may be required if the concrete mixture entrains air above the specified amount.

**505.20.3.4** Air-entraining admixtures shall not be added.

**505.20.4 Testing.** Testing will be done in accordance with [Sec 505.10](#), except that the slump test will be conducted 4 to 5 minutes after discharge from the mixer. During this waiting period, the concrete shall be deposited on the deck and shall not be disturbed.

### 505.20.5 Mixing.

**505.20.5.1** The concrete shall be volumetrically mixed at the bridge site by a continuous mixer in accordance with [Sec 501](#). In addition to other requirements, the mixer shall provide positive control of the latex emulsion into the mixing chamber, and the latex emulsion shall calibrate to within  $\pm 2$  percent of that required. The mixer shall be capable of continuously circulating the latex emulsion and have a flow-through screen between the storage tank and the discharge.

**505.20.5.2** The concrete discharged from the mixer shall be uniform in composition and consistency. Mixing capability shall be such that initial and final finishing operations can proceed at a steady pace. Final finishing shall be completed before the formation of a plastic surface film on the surface.

**505.20.5.3** The moisture content of aggregates at time of proportioning shall be such that water will not drain or drip from a sample. Coarse and fine aggregate shall be so furnished and handled that variations in the moisture content affecting the uniform consistency of the concrete will be avoided. Any aggregate fractions used which vary more than  $\pm 1.0$  percentage point from the mean moisture content established near the start of the day's operations will be subject to rejection. The engineer may permit a change in the mean moisture content, and the moisture content of the aggregate shall then vary not more than  $\pm 1.0$  percentage point from the newly established mean. These provisions shall in no way alter the slump and mixing water requirements of these specifications.

**505.20.5.4** Each drum of latex admixture shall be mechanically agitated or hand rolled until thoroughly mixed prior to being introduced into the mixer storage compartment. Latex admixture that is stored overnight in the mixer storage compartment or during delays in mixing of four hours or more shall be agitated by at least two complete cycles in a continuous circulating pump or by mechanical means in the storage compartment. The flow through screen shall be cleaned immediately prior to beginning proportioning and as often as necessary thereafter. Latex admixtures of different brands shall not be combined together in any manner.

**505.20.6 Surface Preparation.** Surface preparation shall be in accordance with [Sec 505.10](#) except as noted.

**505.20.6.1** Prior to scarifying or chipping on concrete adjacent to latex modified concrete, 96 hours of curing shall have elapsed. If practical, or unless otherwise shown on the plans, all scarifying by mechanical units shall be completed prior to placing any latex modified concrete. Areas from which unsound concrete and patches have been removed shall be kept free of slurry produced by wet sawing or wet scarifying by planning the work so that this slurry will drain away from the completed areas of preparation.

**505.20.6.2** On both old and new decks within 24 hours before latex modified concrete placement begins, the entire surface shall be thoroughly cleaned by sandblasting followed by an air blast, in accordance with [Sec 505.10](#).

**505.20.7 Finishing Equipment.** Placing and finishing equipment shall include hand tools for placement and brushing in freshly mixed latex modified concrete and for distributing it to approximately the correct level for striking-off with the screed.

**505.20.7.1 Finish Machine.** The finishing machine shall be self-propelled and capable of forward and reverse movement under positive control, with a provision for raising all screeds to clear the screeded surface for traveling in reverse. A Gomaco C450 or equivalent self-propelled finishing machine with one or more rollers, augers and 1500 to 2500 vpm vibratory pans shall be used. A drag float may be necessary. Any modifications shall be subject to approval by the engineer.

**505.20.7.2 Support Rails.** Support rails shall meet [Sec 505.10](#).

**505.20.8 Placing and Finishing Concrete.** Placing and finishing shall be in accordance with [Sec 505.10](#) except as noted herein.

**505.20.8.1** Prior to placement of latex modified concrete, the cleaned surface shall be thoroughly wetted for a period of not less than one hour, then covered with polyethylene sheeting until time of placement. The surface shall be damp at the time the overlay is placed. Any standing water in depressions, holes or areas of concrete removal shall be blown out with compressed air. No free water or puddles of standing water will be permitted at time of placement.

**505.20.8.2** Expansion joints and dams shall be formed in the concrete overlay. Formation of the joint by sawing through the overlay will not be allowed.

**505.20.8.3** Some of the latex modified concrete mixture shall be thoroughly brushed onto the wetted, prepared surface immediately ahead of the overlay. Care shall be exercised to ensure that all vertical as well as horizontal surfaces receive a thorough, even coating of mortar from the concrete. The rate of progress shall be controlled so that the mortar from the brushed concrete does not become dry before it is covered with additional concrete as required for the

final grade. Concrete that has been used for brushing shall be disposed of when the mortar is gone.

**505.20.8.4** Texturing shall occur immediately after finishing and before the plastic film forms on the surface. Texturing shall proceed toward the centerline to prevent pulling the concrete away from the curb face. The wire comb should be held at approximately a 20 degree angle to the surface and carefully pressed into the concrete. Care shall be taken not to texture too deep and not to tear the surface. Frequent cleaning of the comb is necessary.

**505.20.8.5** Screed rails and headers shall be separated from the newly placed material by passing a pointing trowel along their inside face. Metal expansion dams shall not be separated from the overlayment. Care shall be exercised to ensure that this trowel cut is made for the entire depth and length of rails or headers after the mixture has stiffened sufficiently to prevent the concrete from flowing back into the cut.

**505.20.8.6** During placement of the overlay, all joints with adjacent concrete shall be sealed with a mortar paste of equal parts cement and fine aggregate, using latex emulsion in lieu of mixing water.

**505.20.8.7** The finished surface shall be promptly covered with a single layer of clean, wet burlap as soon as the surface will support it without deformation. Extreme care shall be taken not to deform the finished surface.

**505.20.8.8** Within one hour of covering with wet burlap, a layer of white polyethylene sheeting shall be placed on the wet burlap. The surface shall remain covered for 48 hours, then be exposed for air curing.

**505.20.8.9** White polyethylene - burlap sheeting thoroughly wetted may be substituted for the white polyethylene sheeting with the approval of the engineer but shall not replace the initial wet burlap.

**505.20.8.10** No surface sealing shall be applied to the latex modified concrete wearing surface.

#### **505.20.9 Limitations of Operations.**

**505.20.9.1** Latex modified concrete shall be placed after sundown and prior to sunup.

**505.20.9.2** No latex modified concrete shall be placed when the ambient or deck surface temperature is above 85 F (30 C). Deck temperature shall be determined in accordance with MoDOT Test Method T20.

**505.20.9.3** No latex modified concrete shall be placed at ambient or deck surface temperatures below 45 F (7 C). Concrete placement may begin when the ambient and deck surface temperatures are 45 F (7 C) and rising. The overlayment shall not be exposed to temperatures below 45 F (7 C). Latex modified concrete placed in cold weather or when the temperature is forecast to be less than 45 F (7 C) shall be protected by the use of a heated weatherproof enclosure, to maintain the minimum specified curing temperature of 45 F (7 C). Any concrete damaged by freezing or which is exposed to a temperature of less than 45 F (7 C) during the first 8 hours after placement shall be removed and replaced at the contractor's expense.

**505.20.9.4** The temperature of the latex modified concrete at time of placement shall be between 45 F (7 C) and 90 F (32 C). If either the aggregate or water is heated, the maximum



temperature for each shall be 100 F (38 C) at the time of addition to the mix. Any method of heating during the mixing of concrete may be used provided the heating apparatus will heat the mass uniformly and avoid hot spots which will burn the material. Cement or aggregate containing lumps or crusts of hardened material or frost shall not be used.

**505.20.9.5** No vehicle traffic shall be permitted on the latex modified concrete surface until the latex modified concrete is at least 96 hours old and has attained a minimum compressive strength of 3000 psi (21 MPa). At temperatures below 55 F (13 C), a longer curing period may be necessary to attain this strength.

**505.20.9.6** Concrete shall not be placed adjacent to a parallel surface course less than 96 hours old; however, this restriction does not apply to a continuation of placement in a lane or strip beyond a joint in the same lane or strip.

**505.20.9.7** Preparation of the area, except scarifying, may be started in a lane or strip adjacent to newly placed surface the day following its placement. If this work is started before the end of the 48 hour wet curing period, the work will be restricted so that any interference with the curing process is held to the minimum practical time only.

**505.20.9.8** In order to avoid locating the longitudinal construction joints in a wheelpath, they shall be placed between designated traffic lanes. The location of the longitudinal joints shall be subject to the approval of the engineer.

**505.20.9.9** Transverse joints in the overlay will be permitted subject to the approval of the engineer. These joints shall be located a minimum of 10 feet (3 m) from the centerline of bent.

**505.20.9.10** A header shall be installed in case of delay in the placement operations exceeding one-half hour in duration. During minor delays of one-half hour or less, the end of the placement shall be protected from drying with several layers of wet burlap.

**505.20.9.11** Adequate precautions shall be taken to protect freshly placed concrete from sudden or unexpected rain. All placing operations shall stop when it starts to rain. The engineer may order removal of any material damaged by rainfall; such material shall be replaced in accordance with these specifications, at the contractor's expense.

**505.20.10 Removal.** Material removal and disposal shall be in accordance with [Sec 505.10](#).

**505.20.11 Repair.** Repair shall be in accordance with [Sec 505.10](#).

**505.20.12 Method of Measurement.** Measurement will be in accordance with [Sec 505.10](#).

**505.20.13 Basis of Payment.** The basis for payment will be in accordance with [Sec 505.10](#).

### **505.30 SILICA FUME CONCRETE**

**505.30.1 Description.** This work shall consist of a wearing surface of silica fume concrete constructed on a prepared surface in accordance with these specifications and in conformity with lines, grades, thickness and typical cross sections shown on the plans or established by the engineer.

**505.30.1.1** A technical representative of the manufacturer of the silica fume admixture shall be present prior to and during batching, mixing and placing of the silica fume concrete during the startup phase. The technical representative shall provide the engineer with written

recommendations supplementing these specifications. The technical representative shall review the contractor's proposed procedures and equipment for all phases of the silica fume concrete overlay work and shall advise the engineer of any deficiencies concerning the procedures and equipment. Work shall not begin until approval is granted by the engineer.

**505.30.1.2** It shall be the contractor's responsibility to notify the manufacturer's technical representative sufficiently in advance of work to provide for trial batches, if needed, or any necessary equipment or procedural changes. The expense of having the manufacturer's technical representative present shall be the contractor's responsibility and no direct payment will be made for this expense.

**505.30.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Type I Cement	1019
Air Entraining Admixture	1054
Retarding Admixture	1054
Water-Reducing Admixture	1054
Polyethylene-Burlap Sheeting	1055
Burlap	1055
Polyethylene Sheeting	1058
Water	1070

**505.30.2.1** Aggregate shall meet the requirements of [Sec 505.10.2](#).

**505.30.2.2** Only one brand of cement will be permitted on a bridge deck. Cements other than Type I will not be permitted. Pozzolanic material (other than silica fume) or portland pozzolan cements shall not be used.

**505.30.2.3** A retarding admixture may be permitted, if recommended by the manufacturer of the silica fume admixture.

**505.30.2.4** Silica fume shall be approved prior to use and meet AASHTO M 307 except as noted herein. If in dry compacted form, the admixture shall be 100 percent silica fume with no admixtures. Silica fume slurries may contain other approved admixtures such as water reducers or retarders if they are included by the manufacturer of the silica fume admixture.

**505.30.2.4.1** The maximum loss on ignition shall be 6.0 percent.

**505.30.2.4.2** Fineness shall be determined. The amount retained when wet sieved on a No. 325 sieve (45  $\mu$ m) shall be 0 percent.

**505.30.2.4.3** The contractor shall furnish to the engineer a manufacturer's certification along with the brand name, batch identification, quantity represented, percent solids, and the type, name and quantity of any admixtures that are included in the silica fume admixture.

**505.30.2.4.4** The manufacturer's certification shall also contain results of recent tests made on samples of the silica fume material taken during production or transfer and indicating conformance with Tables 1 and 2 of AASHTO M 307 and this specification. The supplier shall further certify that the material being furnished conforms to these provisions.

**505.30.2.4.5** For approval prior to use, the supplier shall furnish the same information to the Division Engineer, Materials, P. O. Box 270, Jefferson City, MO 65102 along with any requested samples for testing.

**505.30.2.5** Approved Type F or G high range water-reducing admixtures will be allowed if required or recommended by the supplier of the silica fume admixture.

**505.30.2.6** Liquid silica fume admixture shall be protected from freezing at all times.

**505.30.2.7** All admixtures used shall be compatible with the silica fume admixture and shall be recommended or approved in writing by the technical representative of the supplier of the silica fume admixture.

**505.30.2.8** Grout shall be a mixture of equal parts, by weight (mass), of portland cement and fine aggregate as specified above, 10 percent silica fume solids by weight (mass) of cement and sufficient water to form a stiff slurry. The consistency of this slurry shall be such that it can be applied with a stiff brush or broom to the previously placed concrete in a thin, even coating that will not run or puddle in low spots. For sealing vertical joints, this grout shall be thinned to paint consistency.

### **505.30.3 Concrete Mixture.**

**505.30.3.1** The proportions of cement, silica fume, fine aggregate and coarse aggregate will be designated by the engineer and shall meet the following properties:

Air Content, percent	7 ± 1.5
Slump, inches (mm), maximum	6 (150)
Cement Content, sacks/cubic yard (kg/m <sup>3</sup> )	7.20 - 7.40 (401 - 412)
Water/Cement Ratio, gallons/sack (L/kg), max.	4.40 (0.39)
Silica Fume, % solids by weight (mass) of cement	10
Percent Fine Aggregate (as percent of total fine and coarse aggregate by absolute volume)	50 – 55
High Range Water Reducer	As required

**505.30.3.1.1** The water content shall include all free moisture in the fine and coarse aggregates, water content of the silica fume admixture and water content of the high range water reducer. Air-entraining admixtures are not part of the calculated water content. The water/cement ratio will be computed based on the weight (mass) of Type I cement.

**505.30.3.1.2** For silica fume solutions, the quantity of liquid silica fume admixture needed to furnish the required silica fume solids shall be calculated based on the weight per gallon (mass per liter) and percent solids of the silica fume admixture being used.

**505.30.3.2** The contractor shall designate in the mix design letter what the slump will be when tested on the job. The slump during the placement of the silica fume concrete shall not vary from that slump by more than ± 1.5 inch (± 38 mm).

**505.30.4 Testing.** Testing will be done in accordance with [Sec 505.10](#).

### **505.30.5 Mixing.**

**505.30.5.1** Silica fume concrete shall be batched and mixed in accordance with [Sec 501](#) except as herein specified. Silica fume admixture shall be measured by weight (mass) or volume within a tolerance of  $\pm 2$  percent. A continuous mixer used in conjunction with volumetric proportioning (commonly known as a mobile mixer) will not be allowed.

**505.30.5.2** The silica fume admixture shall be added at the point in the batch sequence as recommended by the manufacturer of the admixture. Silica fume admixture may be added by hand methods.

**505.30.5.3** High range water-reducing admixtures shall be incorporated and mixed into the silica fume concrete mixture in accordance with the silica fume admixture manufacturer's recommendations and as approved by the engineer. Water-reducing admixtures may be added by hand methods. The water-reducing admixture shall not be mixed with the air-entraining admixture nor shall it be added to the same portion of the mixing water as the air-entraining admixture. Either the air-entraining admixture or the water-reducing admixture shall be mixed into the concrete before the other is added.

**505.30.5.4** Truck mixed silica fume concrete shall be initially mixed for not less than 70 revolutions at a rate of not less than 12 revolutions per minute nor more than 18 revolutions per minute. Truck mixed silica fume concrete shall be transported to the work site at agitating speeds of 2 to 6 revolutions per minute. After arriving at the work site and before use, the silica fume concrete shall be mixed for at least 30 revolutions at 12 to 18 revolutions per minute.

**505.30.5.5** If on-site rotating paddle type mixers or on-site rotating drum mixers are used, the length of mixing time and revolution rate shall be as recommended by the silica fume admixture manufacturer.

**505.30.5.6** The silica fume admixture manufacturer's technical representative shall advise the engineer in writing, of proper batching sequence, mixing time, mixing speed and other handling procedures necessary for a uniform, homogeneous mixture meeting the requirements of this specification prior to preparation of silica fume concrete trial batches or placement of any silica fume concrete.

**505.30.5.7** Prior to placement of any concrete in the work, the contractor may be required to prepare trial batches of concrete for tests. Trial batches shall comply with and be paid for in accordance with [Sec 501](#).

**505.30.6 Surface Preparation.** Surface preparation shall be in accordance with [Sec 505.10](#).

**505.30.7 Finishing Equipment.** The finishing machine shall be designed for striking off and finishing silica fume concrete overlay. The finishing machine, screeds, traveling strike off and support rails shall conform to [Sec 505.10](#).

**505.30.8 Placing and Finishing Concrete.** Placing and finishing shall be in accordance with [Sec 505.10](#) except as noted herein.

**505.30.8.1** The cleaned areas to receive the overlay shall be thoroughly and continuously wetted with water at least one hour before placement of the overlay is started, then covered with polyethylene sheeting until time of placement. Any accumulations of water shall be dispersed or removed prior to applying the bonding grout. Immediately before placing concrete, a thin coat of bonding grout shall be scrubbed into the wetted prepared surface, including that portion of curbs against which new concrete is to be placed and the vertical face of previously placed overlay. Care shall be exercised to ensure even coating and that no

excess grout is permitted to collect in pockets. The rate of applying grout shall be limited so that grout does not become dry before it is covered with new concrete.

**505.30.8.2** If grout is allowed to dry out, a header shall be placed, and no further silica fume concrete shall be placed until the old grout has been removed and the surface again sandblasted.

**505.30.8.3** Since silica fume concrete produces very little bleed water, one or both of the following procedures will be necessary under most atmospheric conditions to maintain a surface film until the burlap is placed.

**505.30.8.3.1** A commercially available evaporative retarder may be used judiciously with a misting device, during the finishing process, until the wet burlap is applied, only to prevent the surface of the concrete from drying out. It is not to be used to increase surface workability.

**505.30.8.3.2** Fogging may be done to increase humidity in the area of placement. Any fogging is to be done with nozzles specifically designed for fogging, with a maximum rate of 1 gallon (4 liters) per minute per nozzle.

**505.30.8.4** The surface shall receive a wet burlap cure for at least 7 days. For the first 24 hours, the burlap shall be kept continuously wet by means of an approved automatic sprinkling system. After 24 hours, the contractor may cover the wet burlap with a layer of 4-mil (0.10 mm) white, reflective polyethylene film for the remaining cure time in lieu of using a sprinkling or wetting system. In any case the burlap shall remain wet for the entire 7 day period. Time when the ambient temperature is below 45 F (7 C) will not be counted as cure time. Cure shall be continued if 3000 psi (21 MPa) compressive strength has not been obtained.

**505.30.8.5** The finished deck will be examined for cracking due to any cause. If cracking is found, the engineer will determine whether cracking is detrimental, whether remedial surface repairs are needed, or whether the overlay in the cracked area should be removed and replaced. All remedial surface repairs, removal or replacement shall be done by the contractor at the contractor's expense.

**505.30.8.6** No surface sealing shall be applied to the silica fume concrete wearing surface.

**505.30.9 Limitations of Operations.** Operations shall be limited in accordance with [Sec 505.10](#) except as noted herein.

**505.30.9.1** No vehicle traffic shall be permitted on the silica fume concrete surface for 7 days and in no case until 3000 psi (21 MPa) compressive strength is attained. At temperatures below 55 F (13 C), a longer curing period may be necessary to attain this strength.

**505.30.9.2** No silica fume concrete shall be placed when air temperature or deck temperature are below 45 F (7 C) or above 85 F (30 C). Concrete placement may begin when the air temperature and deck temperature are 45 F (7 C) and rising. Concrete shall not be exposed to freezing temperatures until a strength of 3000 psi (21 MPa) has been attained. Any concrete damaged by freezing shall be removed and replaced at the contractor's expense.

**505.30.9.3** When the weather forecast predicts temperatures of 85 F (30 C), or higher, the contractor shall schedule placing and finishing silica fume concrete during hours in which the ambient temperature will be lower than 85 F (30 C). The mixed concrete when placed shall have a temperature no higher than 85 F (30 C).

**505.30.9.4** Since silica fume concrete may not exhibit bleed water, the probability of plastic shrinkage cracking is increased. At surface evaporation rates above 0.1 lb/ft<sup>2</sup>/hr (0.05 kg/m<sup>2</sup>/hr) plastic shrinkage cracking is probable and the contractor should take precautions such as erecting windbreaks, lowering the mix temperature or delaying operations until ambient temperatures are lower. Fogging the concrete surface will only be allowed, as provided for in this specification. Surface evaporation rates can be predicted from mix temperature, air temperature, relative humidity and wind velocity, using Figure 1 of ACI 308-81 (revised 1986), "Standard Practice for Curing Concrete".

**505.30.10 Removal.** Material removal and disposal shall be in accordance with [Sec 505.10](#).

**505.30.11 Repair.** Repair shall be in accordance with [Sec 505.10](#).

**505.30.12 Method of Measurement.** Measurement will be in accordance with [Sec 505.10](#).

**505.30.13 Basis of Payment.** The basis for payment will be in accordance with [Sec 505.10](#).

# **DIVISION 600**

## ***INCIDENTAL CONSTRUCTION***





## SECTION 601

### FIELD LABORATORIES

**601.1 General.** The contractor shall provide one or more laboratories at the site of work and at locations designated by the engineer. A laboratory shall be furnished for each item of work that is specified in the contract as requiring such a unit. Separate laboratories will not be required for successive items of work when any preceding item has been completed. Additional laboratories may be required for the proper control of the work when simultaneous operations on the same item of work are being carried on at more than one location separated by a distance of one mile or more and separate testing operations are necessary. The engineer will specify the number of laboratories required based on the operations of the contractor.

**601.1.1** The laboratory shall be located and maintained at the site of current operations by the contractor. Work that requires the use of a field laboratory will not be permitted until a laboratory is provided. The laboratory shall remain the property of, and shall be disposed of by the contractor upon completion of the work requiring its use.

**601.1.2** Regardless of the number of field laboratories specified in the plans, the number may be increased, decreased or completely underrun at the discretion of the engineer.

**601.2 Type 1 Field Laboratory.** The laboratory shall meet the following requirements. If required by the engineer, the laboratory shall be a mobile unit so that it may be moved to locations designated by the engineer. The laboratory shall be substantially constructed and weatherproof with wood or concrete floors. It shall have windows on at least two sides and at least one outside door. Windows and doors shall be equipped with screens and locks and the necessary keys shall be furnished by the engineer. The laboratory shall have an area equivalent to 120 square feet (11 m<sup>2</sup>) of floor space. The ceiling shall not be less than 7 feet (2.1 m) high. The laboratory shall have at least one work table 30 inches (760 mm) high with a smooth one-piece top, not less than 8 feet (2.4 m) long and 30 inches (760 mm) wide. The laboratory shall be equipped with a storage shelf, a fire extinguisher, a desk and chair. An electric hot plate or gas burner, having no less than two burners with adjustable temperature controls, and capable of accommodating two 14 x 20 inch (355 x 510 mm) sample pans, shall be provided and connected to an adequate fuel supply or power source as approved by the engineer. A faucet equipped sink capable of accommodating a 14 x 20 inch (355 x 510 mm) sample pan and connected to an operating water source of at least 50 gallon (190 L) capacity shall be provided. The contractor shall keep an adequate supply of potable water available at all times. Lighting facilities of an approved type shall be located to adequately illuminate all work in the interior of the laboratory. When required by the engineer, grounded electrical outlets with 110-120 volts, 60 Hz continuous current and a climate control capable of maintaining an ambient temperature range of 72 F (22 C) to 80 F (27 C) shall be provided.

**601.3 Type 2 Field Laboratory.** The laboratory shall meet the requirements of [Sec 601.2](#), except as follows. The laboratory shall have an area equivalent to 10 feet (3 m) by 20 feet (6 m) of floor space. The laboratory shall be constructed with a dividing wall and doorway to allow for a separate testing work area and an office area suitable for computer operation meeting the engineer's approval. Telephone service shall be provided. The laboratory shall be provided with an exhaust fan capable of moving a volume of air equal to at least ten times the volume of the laboratory each hour. Grounded electrical outlets with 110-120 volts, 60 Hz continuous current and a climate control capable of maintaining an ambient temperature range of 72 F (22 C) to 80 F (27 C) shall be provided.

**601.4 Type 3 Field Laboratory.** The laboratory shall meet the requirements of [Sec 601.3](#), except as follows. At least one of the required windows shall provide a direct view of plant operations. The laboratory shall have an area equivalent to 10 feet (3 m) by 30 feet (9 m) of floor space. A locked storage area for nuclear equipment shall be provided which is at least 15 feet (4.5 m) from the normal work areas. A steel box shall be provided in the storage area with locks for the purpose of storing nuclear equipment in accordance with Nuclear Regulatory Commission specifications. A thermostatically controlled oven, capable of maintaining a minimum temperature of 375 F (191 C) and having a capacity to accommodate at least one standard gallon (4 L) can, shall be furnished and connected to an adequate fuel or power supply. The laboratory shall contain a sieve shaker meeting AASHTO T 27 requirements, with time controls, a minimum sieve stacking height of 28 inches (710 mm) and platform adapters to accommodate 8 or 10-inch (200 or 250 mm) sieves, and a sample splitter meeting AASHTO T 248 requirements, having a minimum length of 20 inches (510 mm) with 2-inch (50 mm) maximum opening size and complete with a minimum of three pans.

**601.5 Type 4 Field Laboratory.** The laboratory shall meet the requirements of [Sec 601.3](#), except as follows. At least one of the required windows shall provide a direct view of plant operations.

**601.6 Basis of Payment.** Unless otherwise specified, no direct payment will be made for Type 1, Type 3 or Type 4 Field Laboratories. Authorized Type 2 Field Laboratories complete in place will be paid for at the contract unit price. Payment will be considered full compensation for all furnishings, maintenance, relocation from site to site on the project as required, all utilities, heating and cooling facilities including operation and fuel, and final removal and disposal of the laboratory.

## SECTION 602

### MARKERS

**602.1 Description.** This work shall consist of constructing markers, of the type required by the contract, at the locations shown on the plans or as directed by the engineer. Markers will be as follows:

- (a) Drain Marker
- (b) Steel Right of Way Marker
- (c) Concrete Right of Way Marker

#### **602.2 Material.**

**602.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Steel Post for Markers	1044

**602.2.2** Right of way and drain marker plaques and fasteners will be furnished at the job site at no cost to the contractor.

**602.2.3** Concrete for setting drain markers and steel right of way markers shall be subject to the approval of the engineer and shall have a cement content of not less than 470 pounds per cubic yard (280 kg/m<sup>3</sup>) of concrete. Concrete right of way markers shall be constructed of Class A-1, B, B-1 or B-2 concrete, or concrete of a commercial mixture meeting the requirements of [Sec 501.14](#).

#### **602.3 Construction Requirements.**

**602.3.1** Steel markers shall be set with the legend facing the centerline of the highway. Posts may be driven, set in concrete or set with a quick setting polyurethane foam in accordance with [Sec 903.3.1.2](#). Posts having battered or mushroomed tops will not be accepted. Posts shall be set vertical at locations shown on the plans or as designated by the engineer and the plaques firmly attached.

**602.3.2** Concrete right of way markers shall be constructed to the design and dimensions shown on the plans. Markers shall be set vertical, with the top flush with the finished ground surface or pavement surface. Where markers are located within or adjacent to an area paved with concrete, the marker shall be separated from the paved area with preformed bituminous filler extending the full depth of the paved area.

**602.4 Basis of Payment.** The accepted quantity of markers will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for concrete, grout or polyurethane if required.

## SECTION 603

### WATER LINE INSTALLATION

**603.1 Description.** This work shall consist of furnishing material for, and installing water lines and appurtenances in conformity with the lines and grades shown on the plans or established by the engineer.

#### **603.2 Material.**

**603.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Concrete	501
Reinforcing Steel for Concrete	1036
	<b>Specification</b>
Ductile Iron Pipe, 3 to 48-inch (75 to 1200 mm) diameters	AWWA C151
Ductile Iron and Gray-Iron Fittings	AWWA C110
Rubber Gasket Joints	AWWA C111
Cement Mortar Lining	AWWA C104
Gate Valves	AWWA C500
Rubber-Seated Butterfly Valves	AWWA C504
Dry-Barrel Fire Hydrants	AWWA C502
Seamless Copper Water Tube	ASTM B 88, Type K (ASTM B 88 M, Type A)

**603.2.2** Pipe and fittings shall be lined, ductile iron and bell and spigot with mechanical or push-on joint.

**603.2.3** Service connections, 2-inch (54 mm) inside diameter or less, shall be seamless copper water tube. Service connections greater than 2-inch (54 mm) inside diameter shall be ductile iron.

**603.2.4** The contractor shall furnish manufacturers' certifications in triplicate certifying that all of the specified tests have been made and that the material and fittings comply with the requirements of the specifications.

#### **603.3 Construction Requirements.**

**603.3.1 General.** Service shall not be interrupted without the approval of the engineer and of the proper utility official. The contractor shall arrange his work to interrupt services the shortest possible time. Prior notice of at least 24 hours shall be given the proper utility official and the engineer before any main is shut off. In no case shall a valve or hydrant be opened or shut without proper authorization.

**603.3.2 Handling of Material.** Material shall be distributed along the site of the work, with each section of pipe unloaded opposite or near the place where it is to be laid in the trench. Pipe, fittings, valves, hydrants and accessories shall be carefully handled by the use of hoists

or skidways to avoid shock or damage. Pipe handled on skidways shall not be skidded or rolled against pipe already on the ground.

### **603.3.3 Trench Construction.**

**603.3.3.1** Trenches shall be excavated so that the pipe can be laid to the alignment and minimum depth shown on the plans, except that alterations may be made to avoid obstructions or to connect an existing line if approved by the engineer. The width of the trench shall be sufficient to permit the pipe to be laid and joined properly and the backfill to be placed and compacted as specified. The contractor shall carefully expose existing water, gas and sewer services, and other underground structures for a sufficient distance ahead of pipe laying to determine the grade and alignment of the pipe to be laid.

**603.3.3.2** The trench shall be prepared to provide a uniform and continuous support for the pipe between bell holes, except that a slight depression may be provided to allow withdrawal of pipe slings or other lifting tackle. Ledge rock, boulders and large stones shall be removed to provide a clearance of at least 6 inches (150 mm) below and on each side of all pipe, valves and fittings for pipe 24 inches (600 mm) or less in diameter, and 9 inches (225 mm) for pipe larger than 24 inches (600 mm) in diameter. If other unsuitable material is encountered at the pipe grade, the trench shall be excavated to at least 3 inches (75 mm) below the grade. Before the pipe is laid, any part of the trench excavated below grade shall be backfilled, at the contractor's expense, with an approved material, placed in thoroughly compacted layers not more than 3 inches (75 mm) thick.

### **603.3.4 Pipe Installation.**

**603.3.4.1** Pipe fittings, valves and hydrants shall be carefully lowered into the trench to prevent damage to water main material and to protective coatings and linings. Water main material shall not be dropped or dumped into the trench. The pipe and fittings shall be inspected for damage and other defects immediately before installation. Precautions shall be taken to prevent foreign material from entering the pipe while it is being placed in the line. If necessary, a heavy, tightly woven canvas bag shall be placed over each end of the pipe or fitting before lowering into the trench. The bag shall be left in place until the connection to the adjacent pipe is ready to be made.

**603.3.4.2** After placing the length of pipe in the trench, the spigot end shall be centered in the bell and the pipe forced home and brought to correct line and grade. The pipe shall be temporarily secured in place with approved, thoroughly tamped backfill material, except at the bells. Cutting of the pipe for inserting valves, fittings or closure pieces shall be done in a neat and workmanlike manner without damage to the pipe or lining. Cut ends and rough edges shall be ground smooth, and for push-on joint connections, the cut ends shall be beveled. Ductile iron may be cut using an abrasive pipe saw, rotary wheel cutter, guillotine pipe saw, milling wheel saw or oxyacetylene torch. Unless otherwise permitted by the engineer, pipe shall be laid with the bell ends facing in the direction of the laying. Where the pipe is laid on a grade of 10 percent or greater, the laying shall start at the bottom. If it is necessary to deflect the pipe from a straight line either in the vertical or horizontal plane, the amount of deflection shall not exceed that shown in Tables I or II. The open ends of the pipe shall be closed by a watertight plug or other suitable means when pipe laying is not in progress. If water is in the trench, the seal shall remain in place until the trench is pumped completely dry. No pipe shall be laid in water.

**603.3.4.3** All bends, plugs, caps and tees shall be provided with a reaction backing. Concrete backing shall be placed between solid ground and the fitting to be anchored. The bearing area of the reaction backing shall be as shown on the plans or as authorized by the engineer. The

backing shall be so placed that the pipe and fitting joints will be accessible for repairs. Concrete for reaction backing shall be any of the mixtures specified in [Sec 501](#), including commercial mixtures meeting the requirements of [Sec 501.14](#). No direct payment will be made for reaction backing.

#### **603.3.5 Joint Assembly.**

**603.3.5.1 Mechanical Joints.** The socket and plain end of the pipe shall be wiped clean and washed with a soap solution. The gasket shall also be washed with the soap solution. The gland shall then be placed on the plain end with the lip extension toward the plain end, followed by the gasket with the narrow edge of the gasket toward the plain end of the pipe. The pipe shall be inserted into the socket and the gasket pressed firmly and evenly into the gasket recess. The joint shall be kept straight during assembly. Deflection, if required, shall be made after joint assembly but before tightening the bolts. The gland shall be pushed toward the bell and centered around the pipe with the gland lip against the gasket. Align bolt holes and insert bolts, with bolt heads behind the bell flange and tighten opposite nuts to keep the gland square with the socket. The nuts shall be tightened with a torque-limiting wrench as follows:

<b>Bolt Diameter in. (mm)</b>	<b>Torque ft-lb (N-m)</b>
5/8 (16)	45 - 60 (61 - 81)
3/4 (19)	75 - 90 (102 - 122)
1 (25)	85 - 100 (115 - 136)
1 1/4 (32)	105 - 120 (142 - 163)

**603.3.5.2 Push-On Joints.** The groove and bell shall be thoroughly cleaned and the gasket inserted making sure that it faces the proper direction and that it is correctly seated. The plain end shall be cleaned of all dirt and foreign material and the gasket lubricant applied in accordance with the pipe manufacturer's recommendations. The plain end shall be checked to make sure that it is beveled, square and free from sharp edges that may damage or dislodge the gasket and cause a leak. The plain end shall then be pushed into the bell of the pipe keeping the joint straight while pushing. Deflection, if required, shall be made after the joint is assembled.

**603.3.5.3** A special adapter shall be used for joining two lines having the same inside diameter and different outside diameters.

#### **603.3.6 Valve Installation.**

**603.3.6.1** Valves shall be set and joined to the pipe at the locations shown on the plans, or as directed by the engineer, in the manner specified for cleaning, laying and joining pipe and fittings. A valve box shall be provided for each valve. The valve box shall not transmit shock or stress to the valve and shall be centered over the operating nut of the valve, with the box cover flush with the finished surface.

TABLE I					
Maximum Deflection Full Length Pipe - Mechanical Joint Pipes					
ENGLISH					
Size of Pipe, in.	Deflection Angle, deg-min	Max Deflection, in.		Approx. Radius of Curve Produced by Succession of Joints, ft	
		18-ft Length	20-ft Length	18-ft Length	20-ft Length
3	8-18	31	35	125	140
4	8-18	31	35	125	140
6	7-7	27	30	145	160
8	5-21	20	22	195	220
10	5-21	20	22	195	220
12	5-21	20	22	195	220
14	3-35	13 1/2	15	285	320
16	3-35	13 1/2	15	285	320
18	3-0	11	12	340	380
20	3-0	11	12	340	380
24	2-23	9	10	450	500
30	2-23	9	10	450	500
36	2-5	8	9	500	550
42	2-0	7 1/2	8	510	570
48	2-0	7 1/2	8	510	570
METRIC					
Size of Pipe, mm	Deflection Angle, deg-min	Max Deflection, mm		Approx. Radius of Curve Produced by Succession of Joints, m	
		5.5 m Length	6 m Length	5.5 m Length	6 m Length
75	8-18	787	889	38	43
100	8-18	787	889	38	43
150	7-7	686	762	44	49
200	5-21	508	559	59	67
250	5-21	508	559	59	67
300	5-21	508	559	59	67
350	3-35	343	381	87	98
400	3-35	343	381	87	98
450	3-0	279	305	104	116
500	3-0	279	305	104	116
600	2-23	229	254	137	152
750	2-23	229	254	137	152
900	2-5	203	229	152	168
1050	2-0	191	203	155	174
1200	2-0	191	203	155	174

TABLE II Maximum Deflection Full Length Pipe - Push-On Joint Pipes					
ENGLISH					
Size of Pipe, in.	Deflection Angle, deg-min	Max Deflection, in.		Approx. Radius of Curve Produced by Succession of Joints, ft	
		18-ft Length	20-ft Length	18-ft Length	20-ft Length
3	5	19	21	205	230
4	5	19	21	205	230
6	5	19	21	205	230
8	5	19	21	205	230
10	5	19	21	205	230
12	5	19	21	205	230
14	3	11	12	340	380
16	3	11	12	340	380
18	3	11	12	340	380
20	3	11	12	340	380
24	2	11	12	340	380
30	2	7 1/2	8	510	570
36	2	7 1/2	8	510	570
42	2	7 1/2	8	510	570
46	2	7 1/2	8	510	570
METRIC					
Size of Pipe, mm	Deflection Angle, deg-min	Max Deflection, mm		Approx. Radius of Curve Produced by Succession of Joints, m	
		5.5 m Length	6 m Length	5.5 m Length	6 m Length
75	5	480	530	63	70
100	5	480	530	63	70
150	5	480	530	63	70
200	5	480	530	63	70
250	5	480	530	63	70
300	5	480	530	63	70
350	3	280	300	104	116
400	3	280	300	104	116
450	3	280	300	104	116
500	3	280	300	104	116
600	2	280	300	104	116
750	2	190	200	155	174
900	2	190	200	155	174
1050	2	190	200	155	174
1150	2	190	200	155	174

**603.3.6.2** Tapping and inserting valves shall be installed in existing mains under pressure, as shown on the plans or as directed by the engineer in accordance with instructions furnished by the manufacturer of the drilling machine, valves and sleeves.

**603.3.7 Hydrant Installation.** Hydrants shall be located as shown on the plans, or as directed by the engineer. Hydrants shall be plumb, with the centerline of the lowest nozzle at



least 12 inches (300 mm) above the finished surface. Each hydrant shall be connected to the main with a 6-inch (150 mm) branch controlled by an independent 6-inch (150 mm) gate valve. A drainage pit 2 x 2 x 2 feet (600 x 600 x 600 mm) deep shall be excavated below each hydrant and filled with coarse gravel or crushed stone, mixed with coarse sand, under and around the elbow of the hydrant to a level 6 inches (150 mm) above the drain port.

**603.3.8 Hydrostatic Testing.** After installation of the pipe, the trenches shall be partially backfilled leaving the joints exposed for examination. The pipe line shall then be subjected to a hydrostatic pressure of 1.5 times the working pressure. The pipe shall be tested between points as designated by the engineer by slowly filling the test section with water by means of a pump connected to the pipe but not before the pipe has been relieved of air through taps made where required. The test pressure shall be maintained for at least 2 hours during which time all exposed joints, fittings, valves and hydrants will be carefully examined. No pipe installation will be accepted until the leakage during a 2-hour test period measured by pumping at not less than the normal operating pressure from a calibrated container into the section of pipe being tested is less than that determined by the formula:

$$L = \frac{ND(P)^{1/2}}{7400}$$

Where:

L = Allowable leakage in gallons (liters) per hour.

N = Number of joints in the length of pipeline tested.

D = Nominal diameter of pipe in inches (millimeters).

P = Average test pressure during the leakage test, in pounds per square inch (pascals) gauge.

At the option of the contractor, the pressure and leakage tests may be made simultaneously. Any defective joints and any defects in pipe, fittings, valves or hydrants revealed during the tests or before final acceptance of the project shall be repaired, or the defective material replaced and again tested until the work is satisfactory, all at the contractor's expense. The pump, connections, gauges and the measuring device shall be furnished by the contractor.

#### **603.3.9 Incidental Construction.**

**603.3.9.1** If necessary to join pipe of dissimilar metals, a method of insulation against the passage of electric current shall be provided as approved by the engineer.

**603.3.9.2** All dead ends on new mains shall be closed with ductile iron plugs or caps with suitable blowoff assemblies.

**603.3.9.3** Existing service connections to any portion of a main to be retired shall be transferred by relocating and connecting to the new main. The relocated portion shall not be smaller than that originally in place. Service connections to be disconnected shall be shut off, disconnected and capped at the shut-off valve or corporation cock.

**603.3.9.4** In relocating meters, the contractor shall furnish and install new meter boxes and covers, meter yokes and such fittings as may be required to complete the relocation.

**603.3.9.5** Connections between new mains and existing mains shall be made only after the new mains have been tested, chlorinated and flushed.

**603.3.9.6** Abandoned water mains shall be plugged and sealed watertight by means of a ductile iron plug or cap, or by covering the end of the pipe with concrete of any of the mixtures specified in [Sec 501](#), including commercial mixtures meeting the requirements of [Sec 501.14](#). The concrete cover shall provide a minimum of 6 inches (150 mm) cover around the outside of the pipe and shall extend a minimum of 6 inches (150 mm) in each direction from the end of the pipe. All existing valves, which will have pressure on one side and an abandoned main on the other side, shall be closed with a ductile iron plug and blocked with reaction backing on the side where the main has been abandoned. A portion of the abandoned pipe shall be removed to allow clearance for the plugging and backing. No direct payment will be made for this work.

**603.3.9.7** Encasement if required shall be one of the following types as specified in the contract:

(a) Conduit which will permit the removal and replacement of the water pipe.

(b) Reinforced concrete placed around the water pipe as shown on the plans. Concrete shall be Class B.

**603.3.10 Backfilling.** Material placed around and 12 inches (300 mm) above the top of the pipe shall be free from cinders, ashes, refuse, boulders, rocks or other unsuitable material. The remainder of the trench shall be backfilled in accordance with the applicable provisions of [Sec 726.6](#).

**603.3.11 Disinfection.** The completed water line installation shall be disinfected in accordance with the provisions of the State Department of Natural Resources. No direct payment will be made for disinfecting water lines.

#### **603.4 Method of Measurement.**

**603.4.1** Measurement of pipe complete in place, including joint accessories and service connections greater than 2 inches (50 mm) inside diameter, will be made to the nearest linear foot (0.5 meter) along the geometrical center of the pipe with no exceptions for valves or fittings. Contract quantities will be used for final payment except as hereinafter provided.

**603.4.2** Rock encountered in trenching will be measured to the nearest cubic yard (cubic meter) and paid for only when Item 603-80.00 Rock Excavation, is included in the contract. Measurement of the yardage to be paid for in rock excavation will be a width 18 inches (450 mm) greater than the inside diameter of the pipe and a depth from the surface of the rock as determined by the engineer to a plane 6 inches (150 mm) below the outside bottom of the pipe or to the bottom of the rock, whichever is higher. The term "Rock Excavation" is defined as that excavation which would be classified as Class C, Sandstone or Igneous Rock Excavation in [Sec 203](#). It shall be the contractor's responsibility to notify the engineer before removing any such material. Any rock excavation removed before the engineer has been notified and has established lines of demarcation will not be measured or paid for.

**603.4.3** Measurement of fittings will be the theoretical weight (mass) to the nearest 5 pounds (1 kg), regardless of type of fitting used, as determined in accordance with AWWA C110. Accessories required for fittings will be considered as part of the fitting. Contract quantities will be used for final payment except as hereinafter provided.

**603.4.4** Measurement of relocating service connections, 2 inches (50 mm) inside diameter or less, will be made per each.

**603.4.5** Measurement of encasement conduit will be made to the nearest linear foot (0.5 m) along the geometrical center of the conduit. Contract quantities will be used for final payment except as hereinafter provided.

**603.4.6** Measurement of reinforced concrete encasement, including reinforcing steel, will be made to the nearest 1/10 cubic yard (0.1 m<sup>3</sup>). Contract quantities will be used for final payment except as hereinafter provided.

**603.4.7** For those items on which final payment is based on contract quantities, final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**603.5 Basis of Payment.** Accepted water line will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for any incidental items necessary to complete the work unless specifically provided as a pay item in the contract. No direct payment will be made for excavation or backfill except as noted in [Sec 603.4.2](#). In relocating service connections, 2 inches (50 mm) inside diameter or less, no direct payment will be made for the pipe or fittings.

## SECTION 604

### MISCELLANEOUS DRAINAGE

#### SECTION 604.10 CONCRETE HEADWALLS, DROP INLETS AND MANHOLES

**604.11 Description.** This work shall consist of the construction of headwalls, drop inlets and manholes in accordance with these specifications, and in conformity with the lines and grades shown on the plans or established by the engineer.

**604.12 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete	1036

All concrete, except that portion placed monolithic with paved surfaces, shall be Class B. Concrete for inverts shall be either Class B, or concrete of a commercial mixture meeting the requirements of [Sec 501.14](#). Material, proportioning, mixing, slump and transporting shall be in accordance with [Sec 501](#). Concrete shall be placed, finished and cured in accordance with the applicable provisions of [Sec 703](#).

**604.12.1** Steps for concrete manholes and drop inlets may be cast iron, aluminum alloy or polypropylene plastic coated reinforcing steel. The portion of the step to be embedded in the concrete shall have a configuration such that it will prevent any pullout. The steps shall have properties such that they will withstand a single concentrated load of 300 pounds (135 kg) without distortion on that portion protruding from the wall. The minimum width of rungs or cleats shall be 10 inches (250 mm) and shaped to prevent the foot from slipping off the side. The step shall project a minimum distance of 4 inches (100 mm) from the wall of the riser or cone section measured from the point of embedment. The steps shall be embedded a minimum distance of 3 inches (75 mm) and shall be spaced vertically at a maximum distance of 16 inches (400 mm).

**604.12.2** Steps for drop inlets may be steel step bars shown on the plans or steps meeting the above requirements.

#### **604.13 Construction Requirements.**

**604.13.1** All pipe built into the walls of the structure shall fit flush with the inside face of the wall. A joint, consisting of one layer of commercially available 55-pound (2666 g/m<sup>2</sup>) smooth roll roofing or a heavy coat of bituminous material, shall be placed around that portion of the pipe extending into the walls of the structure. Steps shall clear all pipes and shall be built in the wall as designated by the engineer. The reinforcement of these structures shall be in accordance with [Sec 706](#) and the excavation shall be in accordance with the applicable portions of [Sec 206](#).

**604.13.2** Steps for concrete manholes and drop inlets shall be embedded by casting in place, mortaring or by friction fit. Steps cast in place shall be set through the forms and secured against displacement before concrete is placed. The cavity receptacle for steps placed by friction fit shall be formed by casting in place a removable mold recommended for use by the manufacturer of the step.

**604.13.3** New manholes for existing sewers shall be constructed as shown on the plans. Cutting the existing sewer will be required to provide inlet and outlet connections to the new structure, and a by-pass line shall be provided around construction at all locations where continuous sewer service is required. Any portion of an existing sewer that is damaged in constructing the new manhole shall be repaired or replaced with new material of a type matching the old, at the contractor's expense.

**604.14 Basis of Payment.** The accepted concrete headwalls, drop inlets and manholes will be paid for in the following manner:

- (a) Class B concrete will be measured and paid for in accordance with [Sec 703](#) for miscellaneous concrete.
- (b) Reinforcing steel will be measured and paid for in accordance with [Sec 706](#).
- (c) Excavation will be measured and paid for in accordance with [Sec 206](#).

**604.14.1** No direct payment will be made for:

- (a) Maintaining service or for cutting the existing sewer.
- (b) Weep holes, including excavation, permeable granular backfill, 4-inch (100 mm) drain tile, screen for inlet or any other work incidental thereto.
- (c) Manhole steps.

#### **SECTION 604.20 ADJUSTING DRAINAGE FACILITIES**

**604.21 Description.** This work shall consist of adjusting manholes, catch basins, inlets and similar items in accordance with the details shown on the plans. Existing frames and covers shall be salvaged and reused if specified in the contract. New manhole steps shall be provided as necessary. New manhole adjusting rings (adapters) shall be provided if specified in the contract.

**604.22 Basis of Payment.** The accepted adjustments of manholes, catch basins and inlets will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for steps or adjusting rings.

#### **SECTION 604.30 ADJUSTING HOUSE SEWER CONNECTIONS**

**604.31 Description.** This work shall consist of laying or relaying sanitary sewer house connections which are to be relocated or which are to be reconnected to new sewers or temporarily removed to permit installation of other items in the contract.

**604.32 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

<b>Item</b>	<b>Section</b>
Vitrified Clay Sewer and Culvert Pipe	<a href="#">1030</a>
Plastic Joint Compound for Pipe	<a href="#">1057.3</a>
Mortar for Pipe Joints	<a href="#">1066.1.1</a>

The size and class of pipe to be used shall meet the requirements of the local authority having jurisdiction over the installation of sewer connections.

**604.33 Construction Requirements.** The excavation for the laying of the pipe, and backfilling of the trench shall be in accordance with the applicable portions of [Sec 726](#). The adjustment shall be made to the line and grade shown on the plans or as directed by the engineer. Where a house sewer connection is relocated or relaid above a water main, Class B concrete, or concrete of a commercial mixture meeting the requirements of [Sec 501.14](#), shall be used to encase the sewer line to a minimum thickness of 6 inches (150 mm). The encasement shall extend to a point where the normal distance from the sewer to the water main is a minimum of 10 feet (3 m).

**604.34 Method of Measurement.** Measurement of adjusting house sewer connections will be made to the nearest foot (0.5 m) along the geometrical center of the adjusted pipe.

**604.35 Basis of Payment.**

**604.35.1** Payment for adjusting house sewer connections, complete in place, including all necessary pipe, tees, bends, wyes, the cutting of and joining new pipe to old pipe or structure, excavation, backfill, traps, fittings and items incidental thereto, will be considered as completely covered by the contract unit price per linear foot (meter).

**604.35.2** Payment for encasement, complete in place, will be made at the contract unit price.

**SECTION 604.40 PIPE COLLARS**

**604.41 Description.** This work shall consist of metal or concrete collars constructed around a pipe joint in accordance with the plans.

**604.42 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Corrugated Metallic-Coated Steel Culvert Pipe, Pipe-Arches and End Sections	<a href="#">1020</a>
Reinforcing Steel for Concrete	<a href="#">1036</a>

Metal pipe for pipe collars shall be of the same thickness and have the same corrugation dimensions as the corrugated metal pipe to be connected. Concrete used for collars shall be Class B, or concrete of a commercial mixture meeting the requirements of [Sec 501.14](#).

**604.43 Construction Requirements.** Pipe collars will be required for the purpose of (1) extending existing pipes where the pipe required for the extension will not form a normal joint with the pipe in place; (2) connecting two different sizes of pipe; and (3) connecting corrugated metal pipe to concrete pipe. If the pipe collar design is not applicable to the type of pipe being extended, the pipe collar shall be modified to ensure a joint connection that will fit the pipe.

**604.44 Basis of Payment.** The accepted quantity of pipe collars will be paid for at the contract unit price.

**SECTION 604.50 CONNECTING PIPE TO EXISTING STRUCTURES**

**604.51 Description.** This work shall consist of joining new pipe to existing manholes, box culverts, drop inlet boxes or sewer pipes where shown on the plans or as directed by the engineer. An opening for the new pipe shall be made through the walls or barrel of the

existing structure or pipe at the proper location and grade. The new pipe shall be properly fitted into place, flush with the inner face of the existing masonry or as nearly so as the engineer considers practicable. After the pipe is in place, the opening around the pipe shall be sealed watertight in an approved manner. Any portion of an existing structure that is damaged in joining the new pipe shall be repaired or replaced with new material of a type matching the old, at the contractor's expense. These requirements shall also be applicable in joining one new pipe to another if the use of a manufactured connection joint is waived by the engineer.

**604.52 Basis of Payment.** No direct payment will be made for connecting pipe to existing structures.

#### **SECTION 604.60 SLOTTED DRAIN**

**604.61 Description.** This work will consist of furnishing and installing slotted drains in accordance with these specifications and as indicated on the plans.

**604.62 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

<b>Item</b>	<b>Section</b>
Slotted Drain	<a href="#">1051</a>

#### **604.63 Construction Requirements.**

**604.63.1** The slotted drain shall be Type A, B or C as shown on the plans.

**604.63.2** If Type C Slotted Drain is specified, the drain shall be installed so that the slanted spacer bars are facing upstream, leaning against the direction of the surface flow.

**604.63.3** Unless otherwise specified on the plans, the slotted drain shall be placed on Class A Bedding in accordance with [Sec 726](#) and backfilled to the top of the grate assembly with concrete meeting [Sec 609.10](#). The upper portion of the backfill may be placed in conjunction with concrete curb or paving operations.

**604.64 Method of Measurement.** Measurement of slotted drain, complete in place, will be made to the nearest foot (0.5 m) along the geometric center of the drain. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**604.65 Basis of Payment.** The accepted quantity of slotted drain, complete in place, including coupling devices and any other necessary fittings, will be paid for at the contract unit price. No direct payment will be made for concrete required for installation of the slotted drain.

## SECTION 605

### UNDERDRAINAGE

**605.1 Description.** This work consists of furnishing and installing underdrains in conformity with the lines and grades shown on the plans or as directed by the engineer and shall include installation of all required drainage media, and backfilling with material as specified or as directed by the engineer.

**605.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Aggregate for Drainage	<a href="#">1009</a>
Geotextile	<a href="#">1011</a>
Geocomposite Edge Drain	<a href="#">1012</a>
Drainage Material	<a href="#">1013</a>
Corrugated Metallic-Coated Steel Pipe Underdrain	<a href="#">1022</a>
Corrugated Aluminum Alloy Pipe Underdrain	<a href="#">1025</a>

**605.2.1** Except as otherwise specified, all underdrain pipes, tubing or geocomposite cores shall be perforated. All special fittings such as caps, wyes, tees and couplings shall be of standard design and manufacture and shall be compatible with the type of pipe, tubing or geocomposite drain to be used. All steel fittings shall be zinc or aluminum coated. All welds and cuts of steel pipe or fittings shall be repaired, after welding, as allowed in [Sec 1020](#).

#### **605.3 Construction Requirements.**

**605.3.1 Pipe-Aggregate Pavement Underdrain.** This work shall consist of placing a continuous pipe-aggregate pavement underdrain under the edge of new pavement as shown on the plans or as directed by the engineer. The aggregate shall be Grade 3 (except not [Sec 1005.1](#), Gradation A material), 4 or 5 drainage aggregate. If not otherwise shown on the plans, underdrain pipe or tubing shall have a nominal internal diameter of 4 inches (100 mm), the trench width shall be not less than 8 inches (200 mm) plus the nominal diameter of the pipe and the depth of drainage aggregate shall be a minimum of 12 inches (300 mm) above the pipe or tubing.

**605.3.1.1** The contractor shall select either plastic or metal pipe or tubing meeting these specifications, except that geocomposite drains shall not be used. Where plastic pipe or tubing is used, any exposed outlet shall consist of metal pipe suitably connected to the plastic except for pavement edge drains. Pavement edge drains shall be provided with outlet pipe and splash pads meeting the requirements of this section.

**605.3.1.2** After placement of the underdrain pipe, the initial lift of backfill material shall be placed around and over the pipe to a compacted depth not to exceed 12 inches (300 mm) above the pipe or tubing. This initial lift shall be compacted by three passes of a vibrating pad or drum-type compactor approved by the engineer. Any remaining backfill shall be placed in loose lift thicknesses not exceeding 6 inches (150 mm) and each lift compacted by two passes of the same equipment.



**605.3.1.3** If a pipe-aggregate pavement underdrain is used as a pavement edge drain on a pavement rehabilitation project, the contractor shall not install the drain until all pavement repair and required undersealing have been completed in the area where it is to be placed.

**605.3.1.4** Pipe-aggregate pavement underdrains under new pavement shall be constructed as shown on the plans. The underdrain shall be lined with geotextile and wrapped. Underdrains underneath stabilized permeable base shall have the geotextile wrapped around the outside edge and over the top of the permeable base.

**605.3.2 Structure Underdrain.** This work shall consist of placing pipe or tubing of the sizes shown in the plans, Type 1 (Subsurface Drainage) geotextile as required or shown on the plans, and drainage aggregate.

**605.3.2.1** When the remaining backfill is coarse aggregate or rock fill, Grade 3, 4 or 5 drainage aggregate shall be used with no geotextile. When the remaining backfill is sand or soil, any drainage aggregate may be used with the following exceptions. For sand backfill and Grades 3, 4 and 5 drainage aggregate or for earth backfill and Grades 2, 3, 4 and 5 drainage aggregate, the backfill material shall be separated from the drainage aggregate with geotextile.

**605.3.2.2** The contractor shall select either plastic or metal pipe or tubing meeting these specifications, except that geocomposite drains shall not be used, and where plastic pipe or tubing is used, any exposed outlet shall consist of metal pipe suitably connected to the plastic.

**605.3.2.3** After placement of the drain pipe or tubing, the initial lift of backfill material shall be placed around and over the pipe to a compacted depth not to exceed 6 inches (150 mm) above the pipe or tubing. This initial lift shall be compacted by two passes of a vibrating pad or drum-type compactor approved by the engineer. Any remaining porous backfill shall be placed in loose lift thicknesses not exceeding 6 inches (150 mm) and each lift compacted by two passes of the same equipment.

**605.3.3 French Underdrain.** This work shall consist of the installation of a drain using a trench, Type 1 (Subsurface Drainage) geotextile lining, and Grade 3 or 4 drainage aggregate.

**605.3.3.1** Unless otherwise specified, both the trench width and depth of drainage aggregate shall be not less than 18 inches (450 mm). Where directed, the trench above the drainage aggregate shall be backfilled with well compacted suitable earth.

**605.3.3.2** Drainage aggregate shall be placed in lifts not to exceed 18 inches (450 mm) in thickness and compacted in a manner meeting the approval of the engineer.

**605.3.3.3** All french underdrains shall be daylighted at discharge ends with minimum 10-foot (3 m) lengths of perforated 6-inch (150 mm) diameter metal pipe placed at or within 3 inches (75 mm) of the flowline.

**605.3.4 Geocomposite Pavement Edge Drain.** This work shall consist of furnishing and installing geocomposite pavement edge drain at the locations and in conformity with the lines and grades, shown on the plans or as directed by the engineer.

**605.3.4.1** The contractor shall furnish to the engineer a copy of the drain manufacturer's printed instructions for installing the edge drain at least two weeks prior to installation. Except as herein noted, the installation of the drain shall be in accordance with the manufacturer's printed instructions.

**605.3.4.2** After installation, the drain shall be promptly backfilled, compacted and covered.

**605.3.4.3** The drain shall be placed against the pavement side of the trench and held in place while backfill is placed to a compacted height of 6 inches (150 mm), plus or minus 1 inch (25 mm), using a vibratory wheel or plate compactor with a rated impact force of approximately 5000 pounds (34 MPa). The placement of the edge drain and placement of the first lift of backfill shall be accomplished in a single continuous operation. After the first lift of backfill has been placed, the remainder of the backfill shall be placed and compacted by a vibratory compactor to the satisfaction of the engineer. Material excavated from the trench may be used for backfill, except that all backfill shall pass a 2-inch (50 mm) sieve. At the contractor's option, Grade 1 drainage aggregate may be used in two lifts and flooded with clean water to compact each lift. In that case, the drain shall be placed against the shoulder side of the trench.

**605.3.4.4** Each length of drain shall be joined to the adjacent length prior to installation. Splices shall keep adjoining lengths in proper alignment, shall not separate during installation, shall have the same or greater compressive strength than the geocomposite drain and shall be sealed against infiltration of the backfill material.

**605.3.4.5** The contractor shall not install the drain until after all pavement repair and required undersealing have been completed in the area where edge drain is to be placed.

**605.3.5 Outlet Pipes and Splash Pads.** This work shall consist of furnishing and installing outlet pipes and splash pads for pipe-aggregate pavement edge drain and geocomposite pavement edge drain at the locations and in conformity with the lines and grades shown on the plans or as directed by the engineer.

**605.3.5.1** Unless otherwise shown, outlet pipes shall be installed perpendicular to the drain, with a minimum of two percent gradient and kept as far as possible above the ditch flowline.

**605.3.5.2** Concrete for splash pads shall be air-entrained and Class B, B-1 or concrete of a commercial mixture meeting the requirements of [Sec 501](#).

**605.3.5.3** Construction requirements for the splash pads shall be in accordance with the applicable requirements of [Sec 609](#). In addition, the contractor shall perform the excavation necessary for the construction of each splash pad in such a manner that a minimal amount of backfilling will be necessary. If the excavation is done to neat lines, forming will not be required.

**605.3.5.4** Outlet pipes shall be 4-inch (100 mm) diameter non-perforated, schedule 40 PVC pipe. Outlet connections to pipe-aggregate pavement edge drains shall be with "two way cleanout" connectors.

**605.3.5.5** Outlet pipe trenches shall not be cut prior to installation of the edge drain. Outlet installation shall be completed promptly and, in all cases, within 72 hours of edge drain installation except with the express approval of the engineer. The trench shall not be backfilled until the installation is inspected and approved by the engineer.

**605.3.5.6** Backfilling of excavations for outlet pipe and splash pads shall be performed in accordance with applicable provisions of [Sec 203](#). Should additional material be needed to complete the backfill, suitable material meeting the approval of the engineer shall be provided by the contractor at no additional cost.

**605.3.6 General Geotextile Requirements.** Except where otherwise provided in the plans or contract, Type 1 (Subsurface Drainage) geotextile shall be provided with all pipe-aggregate and french underdrains.

**605.3.6.1** Except as otherwise specified, geotextile shall be used to line underdrain trenches and to completely envelope any drainage aggregate in trenches except that a geotextile will not be required when Grade 1 drainage aggregate is used. Only partial envelopment may be required when the underdrain abuts or is overlain by an approved open graded base course or other drainage medium.

**605.3.6.2** A drainage geotextile wrap or sock shall envelope perforated drainage pipe or tubing when Grade 1 or 2 drainage aggregate is used, or whenever any portion of a perforated pipe used as a discharge pipe is backfilled with soil.

**605.3.6.3** During shipment and storage, geotextiles shall be protected from direct sunlight, ultra-violet rays, temperatures greater than 140 F (60 C), mud, dust and debris.

**605.3.6.4** Geotextile for structure drains shall be as shown in the plans.

**605.3.7 General.** Although probable locations of underdrains are shown on the plans, the contractor shall perform work only at such locations as are specified or approved in writing by the engineer.

**605.3.7.1** Trenches for underdrains shall be carefully excavated true to line and grade and to the width and depth shown on the plans or as directed by the engineer.

**605.3.7.2** Any underdrain trenching which results in an uneven trench bottom or exposes soft, yielding or unstable ground in the trench bottom shall be undergraded as required and backfilled with drainage aggregate material of sufficient thickness to ensure maintenance of proper alignment and gradient for all subsequent operations.

**605.3.7.3** Any required drain pipe or tubing shall be firmly bedded and carefully aligned. The pipe or tubing shall be laid with perforations down if the perforations are not uniformly distributed around the circumference of the pipe or unless otherwise shown in the plans. Sections shall be jointed with approved fittings. Dead ends of pipe shall be completely closed by means of caps or plugs. Outlets shall be protected with rodent screens inserted a distance equal to one to two pipe diameters in a manner ensuring a secure friction-tight fit. Where shown on the plans or directed by the engineer, the outlet ends shall be connected to drain into drop inlets or manholes.

**605.3.7.4** Backfilling shall be carefully done so that any included pipe or tubing will not become displaced. The required drainage aggregate material shall be placed to the dimensions shown on the plans and as specified herein.

**605.4 Method of Measurement.** Measurement will be made to the nearest linear foot (0.5 m) for each type of underdrain along the centerline of the drain, center to center of fittings and junctions.

#### **605.5 Basis of Payment.**

**605.5.1** The accepted quantity of each type of underdrain, complete in place, will be paid for at the contract unit price per linear foot (meter), or at an adjusted unit price per linear foot (meter) as described herein. Any overrun or partial or complete underrun of contract quantity will not be considered as basis for claim. No direct payment will be made for excavating the

trench, connecting underdrains to drop inlets or manholes, nor for backfilling and backfill material. Outlet pipes will not be separately paid for except in combination with any required splash pad.

**605.5.2** Adjustments in the contract unit price per linear foot (meter) of underdrain will be made in accordance with the following schedule where the engineer directs increased depth of excavation from that shown in the plans. For purposes of determining the adjusted price, the excess depth of excavation will be averaged for the entire length of the drain if less than 100 feet (30 m) and, if more than 100 feet (30 m), shall be subdivided into 100-foot (30 m) increments plus any remaining fraction. Any required undergrading to provide 3-inch (75 mm) bedding of drainage aggregate where geotextile trench lining is omitted shall not be included in any calculation of excess depth of excavation for pay purposes.

Average Excess Depth of Excavation	Adjusted Price
0 to 6 inches (0 to 150 mm)	Contract Price
6 to 18 inches (150 to 450 mm)	Contract Price + 25%
18 to 30 inches (450 mm to 750 mm)	Contract Price + 50%
> 30 inches (750 mm)	To be established by supplemental agreement

**605.5.3** Eight-inch (200 mm) non-perforated underdrain pipe used with drain basins will be paid for at the contract unit price. Excavation for placing the pipe will be measured and paid for as Class 3 Excavation in accordance with [Sec 206](#).

**605.5.4** Payment for plan quantity of outlet pipes and splash pads, in combination, will be made at the contract unit price bid per each "Splash Pad".

#### SECTION 605.10 CLASS A UNDERDRAIN

**605.11 Description.** This work shall consist of pipe placed for subdrainage purposes in conformity with the lines and grades shown on the plans or as directed by the engineer, and shall include excavating the trench and backfilling with material as specified or directed.

**605.12 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Porous Backfill Material	<a href="#">1009.2</a>
Corrugated Metallic-Coated Steel Pipe Underdrain	<a href="#">1022</a>
Corrugated Aluminum Alloy Pipe Underdrains	<a href="#">1025</a>

The contractor may select the type of underdrain pipe proposed to be furnished.

**605.12.1** Except as otherwise specified, all underdrain shall have a nominal internal diameter of 6 inches (150 mm) and shall be perforated. All special fittings, including caps, wyes, tees, reducers, elbows, turns and couplings, shall be of standard design and manufacture. All couplings, joints and all special fittings shall be galvanized after welding or all welds and metal adjacent to the welds shall be painted, after welding, with two coats of single component inorganic zinc or organic zinc-rich paint, meeting the approval of the engineer. Screens shall be of 2 x 2 mesh, No. 19 gage (1 mm), galvanized wire cloth, approximately 1/2-inch by 1/2-inch (13 x 13 mm) openings.

### **605.13 Construction Requirements.**

**605.13.1** Although probable locations of underdrains are shown on the plans, the contractor shall perform work only at such locations as are specified in writing by the engineer.

**605.13.2** The trench for underdrains shall be carefully excavated true to line and grade and to the width and depth shown on the plans or as directed by the engineer.

**605.13.3** The pipe shall be firmly bedded in the trench. Pipe sections shall be joined with approved connecting bands. Dead ends of pipe shall be completely closed by means of caps securely affixed to the pipe. Discharge ends shall be protected with screens securely fastened in place by means of galvanized wire. Where shown on the plans or directed by the engineer, the outlet ends shall be connected to drain into drop inlets or manholes.

**605.13.4** Backfilling shall be carefully done so that the pipe will not become displaced. The required porous backfill material shall be placed to the dimensions shown on the plans.

**605.14 Method of Measurement.** Measurement will be made to the nearest linear foot (0.5 m) for each underdrain along the centerline of the drain, center to center of fittings and junctions.

### **605.15 Basis of Payment.**

**605.15.1** The accepted quantity of Class A underdrain, complete in place, will be paid for at the contract unit price per linear foot (meter), or at an adjusted unit price per linear foot (meter) as determined in [Sec 605.15.2](#). Any overrun or partial or complete underrun of contract quantity will not be considered as basis for claim. No direct payment will be made for excavating the trench, connecting underdrains to drop inlets or manholes, nor for backfilling and backfill material.

**605.15.2** For the purpose of determining the price to be paid per linear foot (meter) of underdrain, the underdrain will be laid off in 10-foot (3 m) increments beginning at one end of the pipe, and the space below the elevation of the bottom of the trench on the plans shall be divided into 12-inch (300 mm) depth increments; only the nearest full increment will be considered in either case. If the average depth of trench excavated in a 10-foot (3 m) increment is not more than 6 inches (150 mm) below the depth shown on the plans, adjustment in the unit price will not be made and the contract price shall apply. If the average depth of trench in a 10-foot (3 m) increment is more than 6 inches (150 mm) and not more than 18 inches (450 mm) below the plan elevation of the bottom of the trench, underdrains, within such horizontal limits, will be paid for at 125 percent of the contract unit price. If the average depth is more than 18 inches (450 mm) and not more than 30 inches (750 mm), payment will be at 150 percent of the contract unit price; for any 12-inch (300 mm) increment of depth, or fraction thereof, below the 30-inch (750 mm) depth, 25 percent of the contract unit price will be added.

**605.15.3** Eight-inch (200 mm) unperforated underdrain pipe used with drain basins will be paid for at the contract unit price. Excavation for placing the pipe will be measured and paid for as Class 3 Excavation in accordance with [Sec 206](#).

### **SECTION 605.20 CLASS B UNDERDRAIN**

**605.21 Description.** This work shall consist of pipe (generally for draining porous or other backfill adjacent to concrete masonry construction) placed in conformity with the lines and grades shown on the plans, or as directed by the engineer. The underdrain pipe shall be of the

size or sizes shown and may be corrugated metal, perforated corrugated metal or combinations of such pipe unless a specific type is specified in the contract. Perforated pipe shall be laid in a prepared bed of porous backfill.

**605.22 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Porous Backfill Material	<a href="#">1009.1</a>
Corrugated Metallic-Coated Steel Pipe Underdrain	<a href="#">1022</a>

Pipe underdrains shall be perforated unless otherwise specified in the contract.

**605.22.1** All special fittings, including caps, wyes, tees, reducers, elbows, turns and couplings, shall be of standard design and manufacture. All couplings, joints and all special fittings shall be galvanized, after welding, or all welds and metal adjacent to the welds shall be painted after welding with two coats of single component inorganic zinc or organic zinc-rich paint, meeting the approval of the engineer.

**605.23 Construction Requirements.** The pipe shall be laid to the grade and alignment shown on the plans, with the perforations down. The pipe shall be joined with approved coupling bands. Where a section of pipe is cast into concrete, the remaining pipe shall be joined to these sections with connecting bands. The porous backfill material shall be placed so that the pipe will not become displaced and shall be firmly tamped under and around the entire pipe. Discharge ends shall be protected by approved methods to prevent obstruction until connections to outlets are installed.

**605.24 Method of Measurement.** Measurement will be made to the nearest linear foot (0.5 m) for each underdrain along the centerline of the pipe, center to center of fittings and junctions.

**605.25 Basis of Payment.** The accepted quantity of Class B underdrain, complete in place, will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for excavating the trench nor for backfilling and backfill material.

#### **SECTION 605.30 CLASS C UNDERDRAIN**

**605.31 Description.** This work shall consist of either a French underdrain or a drain tile underdrain, or combinations of these types placed in conformity with the lines and grades shown on the plans, or as directed by the engineer. The type of underdrain to be constructed at a particular location will be shown on the plans.

**605.32 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Porous Backfill Material	<a href="#">1009.2</a>
Clay Drain Tile	<a href="#">1031</a>

If drain tile underdrain is specified in the contract, the contractor may select the type of underdrain tile proposed to be furnished.

**605.33 Construction Requirements.**

**605.33.1** Although probable locations of underdrains are shown on the plans, the contractor shall install underdrains only at such locations as are specified in writing by the engineer.

**605.33.2 Drain Tile Underdrain.** The trench shall be carefully excavated to the width and depth required to permit the tile to be laid to the proper grade. The tile shall be bedded firmly in the trench with ends closely joined and each section of the tile shall have a firm bearing throughout its length. The top of all joints shall be covered with strips of tar paper not less than 8 inches (200 mm) wide. No joint opening shall be more than 1/2 inch (13 mm) and any joint opening 1/4 inch (6 mm) or more shall have a piece of broken tile placed over the tar paper covering. All junctions, bends and turns shall be made with fittings of standard manufacture. Suitable caps or plugs shall be provided and installed to close the dead ends of the underdrains. Screens of 2 x 2 mesh, No. 19 gage (1 mm), galvanized wire cloth, approximately 1/2-inch by 1/2-inch (13 x 13 mm) openings, shall be provided and securely fastened over the outlet ends by means of galvanized wire. Any tile which is not in true alignment or which shows signs of settlement after it has been laid shall be taken up and relaid to the proper grade.

**605.33.2.1** Backfilling shall be carefully done so that the tile will not be displaced. Porous backfill shall be placed to the dimensions shown on the plans and covered with a layer of tar paper as indicated. For that part of the trench in shoulders, the trench above the porous backfill shall be filled with suitable backfill, well compacted. Underdrains shall be kept free from accumulations of silt, debris and other foreign matter during construction.

**605.33.3 French Drain.** At locations shown on the plans, French drains shall be constructed in the subgrade and through the shoulders to provide drainage. French drains shall have a trench of the dimensions shown on the plans, filled with porous backfill material. For that part of the trench in shoulders, the trench above the porous backfill shall be filled with suitable earth, well compacted.

**605.34 Method of Measurement.** Measurement will be made to the nearest linear foot (0.5 m) for each underdrain.

**605.35 Basis of Payment.** The accepted quantity of Class C underdrain, complete in place, will be paid for at the unit price for each of the pay items included in the contract. Any overrun or partial or complete underrun will not be considered as a basis for claim. No direct payment will be made for excavating the trench nor for backfilling the backfill material.

## SECTION 606

### GUARDRAIL AND GUARD CABLE

**606.1 Description.** This work shall consist of furnishing and erecting guardrail and guard cable in conformity with the lines and grades shown on the plans or as established by the engineer.

**606.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Guardrail and Guard Cable Material	<a href="#">1040</a>

**606.3 Construction Requirements.** Guardrail and guard cable shall be placed at locations shown on the plans or designated by the engineer.

#### **606.3.1 Posts.**

**606.3.1.1** Wood posts for Breakaway Cable Terminal (BCT) and end anchor shall be installed according to the plans.

**606.3.1.2** Unless otherwise specified, wood posts shall be set in dug or bored holes, in a vertical position and true to line and grade. Holes shall be of a size sufficient to permit thorough compacting of the backfill around the posts. The backfill material shall be dry sand, placed in layers not exceeding 12 inches (300 mm) thick to a height 12 inches (300 mm) below the finished grade. After erecting and adjusting the rail to true line and grade, the sand backfill shall be compacted by flooding. The final 12 inches (300 mm) of backfill, consisting of suitable earth material, shall then be compacted in not more than 6-inch (150 mm) lifts. Surfaced area around the posts shall be restored to its former condition.

**606.3.1.3** Steel posts may be set by the method described in [Sec 606.3.1.2](#) or may be driven by a power hammer. Any mushrooming of the top of a post shall be removed, and damaged spelter coating on galvanized posts shall be field repaired.

**606.3.2 Beams.** Beams shall be spliced by lapping in the direction of traffic. The use of 25-foot (7.62 m) sections of beam rails, and channels if required, will be permitted for bridge anchor sections, and elsewhere where true line and grade can be maintained.

**606.3.3 Cable.** Guard cable shall be strung directly from the reel and shall be pulled tight after the initial anchoring. The cable shall then be attached to the second anchor assembly with all turnbuckles fully opened. The cable shall be completely anchored before being attached to the line posts.

**606.3.4 Field Repair.** Galvanized material shall be handled in a manner to avoid damage to the surfaces. Field punching, reaming or drilling of any of the galvanized material shall not be done, except as may be approved by the engineer to provide for lapped beams, or for changes in location of splices necessitated by field clearances. Any galvanized material on which the spelter coating has been damaged will be rejected or may, with approval of the engineer, be repaired by the zinc alloy stick method in accordance with [Sec 712](#).



**606.3.5 Scheduling.** At locations where the adjacent travel or auxiliary lane is open to traffic during non-working hours, the contractor shall schedule guardrail and guard cable installation to ensure guardrail beam or guard cable is fully and properly attached to all installed posts at the end of each work day. Where guardrail or guard cable removal and replacement is required and the adjacent travel or auxiliary lane is open to traffic during non-working hours, the contractor shall remove no more guardrail or guard cable than can be replaced in the same day. As an alternative, the contractor may provide concrete traffic barrier with acceptable end treatment between the adjacent lane and any unattached installed post. Should the contractor choose this option, the contractor shall submit a traffic control plan to the engineer for approval. The contractor will not be compensated for any additional traffic control items required to perform this work. In all cases, the contractor shall ensure that the guardrail or guard cable installation is fully anchored before opening the adjacent lane to traffic.

**606.4 Method of Measurement.**

**606.4.1** Measurement of guardrail will be made to the nearest 1/2 linear foot (0.5 m) for each increment along a line passing through the centerline of each post, and totaled to the nearest linear foot (0.5 m) for the sum of the increments on the project. The length will be measured separately for each type from the center of the end post to the center of end post, excluding bridge anchor sections and end anchors.

**606.4.2** Measurement of guard cable will be made to the nearest 1/2 linear foot (0.5 m) for each increment, from center of end post to center of end post, and totaled to the nearest linear foot (0.5 m) for the sum of the increments on the project.

**606.5 Basis of Payment.** The accepted quantities of guardrail, BCT, end anchors, bridge anchors and guard cable, complete in place, will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for end sections or terminal ends.

## SECTION 607

### CHAIN-LINK FENCING

#### SECTION 607.10 CHAIN-LINK FENCE

**607.11 Description.** This work shall consist of furnishing and erecting chain-link fence and gates, complete in place, in conformity with the lines shown on the plans or as established by the engineer.

**607.12 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Chain-Link Fence	<a href="#">1043.2</a>

The contractor may select either zinc-coated steel, aluminum-coated steel, aluminum alloy or vinyl coated steel fencing material, except that the same kind of material shall be used throughout the project. Walk gates and drive gates, if required, shall be of the same kind of material as that selected for the fence.

#### **607.13 Construction Requirements.**

**607.13.1** The contractor shall fill, cut or trench where necessary to produce a smooth and uniform ground surface so the bottom of the fabric is not more than 3 inches (75 mm) above the finished ground line. Posts shall be set plumb, true to line and grade in concrete footings, and shall be located as shown on the plans or as directed by the engineer. Footings shall be of Class B concrete, or concrete of a commercial mixture meeting the requirements of [Sec 501.12](#). The concrete shall be of a uniform thickness around the post, and the footings shall have cone or dome shaped tops. At the option of the contractor, a quick setting polyurethane foam in accordance with [Sec 903.3.1.2](#) may be used for line posts in lieu of concrete. At the option of the contractor, line posts may be driven in lieu of setting in concrete or polyurethane. If the contractor elects to drive line posts, they shall be of the length and driven to the depth shown on the plans. If posts cannot be driven to depths shown because of rocky soils or other conditions, they shall be removed and placed in footings. Post tops shall be protected against damage and all posts damaged during installation shall be removed and replaced.

**607.13.2** Fabric shall not be attached to posts until the concrete in the footings is at least five days old, and shall be attached to the posts on the side shown on the plans. Fabric shall be securely attached to end, corner, gate and pull posts in accordance with manufacturer's recommendations. It shall be attached to tension wire with hog rings spaced as shown on the plans. The fabric shall be attached to line posts with wire ties or bands, and spaced in accordance with manufacturer's recommendations. All fabric shall be taut before it is attached to line posts or tension wire.

**607.13.3** Walk gates and drive gates complete with hinges, latches, braces, stops and locking devices shall be installed at locations shown on the plans. Drive gates shall have an approximate full circle opening swing. Walk gates shall have positive stops to prevent the gates from swinging into the right of way.

**607.14 Method of Measurement.** Measurement of chain-link fence will be made to the nearest linear foot (0.5 m) measured along the slope of the fabric but shall not include gates.

**607.15 Basis of Payment.** The accepted quantity of chain-link fence, complete in place, will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for concrete footings or for post hole excavation or for excavation and embankment necessary to smooth the area under the fence.

**SECTION 607.20 WOVEN WIRE FENCE**

**607.21 Description.** This work shall consist of furnishing and erecting woven wire fence, complete in place, in conformity with the plans, and at locations as shown on the plans, or established by the engineer.

**607.22 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Woven Wire Fence	<a href="#">1043.3</a>

**607.23 Construction Requirements.**

**607.23.1** Wood corner, end, brace and pull posts shall be set in drilled or dug holes. At the option of the contractor, steel or wood line posts may be set in drilled or dug holes, or may be driven into place provided the method of driving meets the approval of the engineer and does not damage the post. All wood posts set in drilled or dug holes shall have the butt end down, and shall be backfilled with suitable material thoroughly tamped. Wood line posts that are to be driven shall have the small end machine pointed at the plant before being treated.

**607.23.2** If surfaces of treated wood posts have been damaged, or if framing at the site is required, the damaged or resulting untreated surfaces shall be field treated with two liberal brush coats of commercially available preservative of the same type used for the original treatment. The second coat shall be applied after the first coat is absorbed. Creosote preservative shall be hot when applied.

**607.23.3** Posts shall be set plumb, true to line and grade. Corner post assemblies shall be set at all horizontal angle points greater than 15 degrees in the line of fence. Pull post assemblies shall be set at all vertical angle points greater than 15 degrees but at not greater than 660-foot (200 m) intervals. Footings for steel posts and braces shall be of Class B concrete, or concrete of a commercial mixture meeting the requirements of [Sec 501.14](#).

**607.23.4** Fabric and barbed wire shall be pulled taut by approved handpowered mechanical means before it is attached to any line post. The bottom of the fabric shall be not more than 3 inches (75 mm) above the ground at any point, and necessary excavation along the fence shall be performed to obtain the specified clearance. Filling of depressions will not be permitted except where old channels are backfilled after drainage has been relocated. Any space left by depressions shall be filled by spacing strands of barbed wire as indicated on the plans.

**607.23.5** Walk gates and drive gates complete with hinges, latches, braces, stops and locking devices shall be installed at locations shown on the plans. They shall be constructed in accordance with the requirements of gates for chain-link fence, except the filler shall be woven wire fabric of the same kind as used for the fence. Direction of swing of gates shall be as shown on the plans or as directed by the engineer.

**607.23.6** Water gates shall be installed at locations shown on the plans and the contractor shall modify the typical installation to fit the conditions encountered.

**607.24 Method of Measurement.** Measurement of woven wire fence will be made to the nearest linear foot (0.5 m) measured along the slope of the fabric, but shall not include gates.

**607.25 Basis of Payment.**

**607.25.1** The accepted woven wire fence, complete in place, will be paid for at the contract unit price per linear foot (meter) which will include all material, excavating for posts, backfilling, clearing of fence row, trenching for fabric, placing extra strands of barbed wire for depressions and all other incidental work or material.

**607.25.2** The accepted walk gates and drive gates, complete in place, will be paid for at the unit price for each of the pay items included in the contract.

**607.25.3** No direct payment will be made for construction or installation of water gates.

## SECTION 608

### CONCRETE MEDIAN, MEDIAN STRIP, SIDEWALK, STEPS AND PAVED APPROACHES

**608.1 Description.** This work shall consist of constructing concrete median, median strip, sidewalk, steps and paved approaches in conformity with the lines, grades, dimensions and typical sections shown on the plans or as directed by the engineer. Concrete median shall consist of a paved median constructed on a prepared subgrade. Concrete median strip shall consist of a paved median strip laid over and doweled to a previously constructed pavement.

**608.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete Structures	<a href="#">1036.1</a>
Steel Wire Fabric for Concrete Pavement	<a href="#">1036.2</a>
Material for Joints	<a href="#">1057.1</a>

**608.2.1** Concrete sidewalk and steps shall be constructed of Class B concrete. Concrete median, median strip and paved approaches 6 inches (150 mm) or greater in thickness shall be constructed of Pavement concrete. Concrete median, median strip and paved approaches less than 6 inches (150 mm) in thickness shall be constructed of either Class B concrete or Pavement concrete. Material, proportioning, air-entraining, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#). Concrete shall be placed, finished and cured in accordance with the applicable provisions of [Secs 502](#) and [703](#).

#### **608.3 Construction Requirements.**

**608.3.1** All items shall be constructed on a subgrade compacted to the specified density of the applicable subgrade material. The subgrade shall be checked by means of a template prior to placing concrete. Large rocks and boulders found in the subgrade shall be removed to a minimum of 6 inches (150 mm) below the bottom of the proposed concrete and the space shall be filled with suitable material. Forms shall be metal or sound, dressed lumber, straight, free from warp, of sufficient strength to resist springing during construction and of a height equal to the full depth of the item to be constructed. Wood forms shall have a minimum nominal thickness of 2 inches (50 mm) except where flexible forms are used. Flexible forms will be required for all curved form lines, except that straight steel form sections 10 feet (3 m) long or less may be used for form lines having a radius greater than 200 feet (60 m). Straight steel form sections 5 feet (1.5 m) long will be acceptable for form lines having a radius of not less than 100 feet (30 m). The forms shall be thoroughly cleaned, well oiled, securely staked, braced and held to the required line and grade.

**608.3.2** Required reinforcement and tie bars shall be held in the specified position by bar chairs or other approved devices during the placing of concrete.

**608.3.3** Concrete median strip shall be doweled to the pavement with tie bars as shown on the plans. Where the median strip is to be built on pavement constructed on a previous project, or on pavement that has been used by traffic before the median strip is placed, the contractor shall drill holes and grout in the tie bars. If the median strip is included with the paving contract and will be constructed before the pavement is opened to traffic, the contractor may

insert the tie bars into the pavement immediately after it has been finished, or the contractor may preform the holes and grout in the tie bars when the median strip is constructed. The holes shall be thoroughly cleaned just before the tie bars are grouted in place.

**608.3.4** Joints for all items shall be constructed at such intervals and locations as shown on the plans or as directed by the engineer.

**608.3.4.1** Transverse joints for concrete median shall be sawed joints of the same dimensions as required for concrete pavement and spaced approximately the same as transverse joints in non-reinforced concrete pavement. Load transfer devices will not be required. Longitudinal joints between the median and curb shall be constructed of either non-extruding preformed joint material, or one layer of commercially available 55-pound (2666 g/m<sup>2</sup>) roll roofing. Sawed joints shall be sealed in accordance with [Sec 502.11.4](#).

**608.3.4.2** Transverse joints in concrete median strip shall be constructed of non-extruding preformed joint material extending from top to bottom. Joints shall be constructed over each joint and major crack in the pavement, but at not less than 10-foot (3 m) intervals.

**608.3.4.3** Transverse joints for concrete sidewalks shall be either sawed joints 1/8 inch (3 mm) wide x 1/2 inch (13 mm) deep or 1/2 inch (13 mm) deep dummy joints, made with a finishing tool. Preformed fiber joints shall be as shown on the plans.

**608.3.5** Concrete shall be placed on the prepared and sprinkled subgrade and shall be consolidated and struck off to the required thickness. Mechanical consolidating and finishing equipment may be used provided satisfactory results are attained. The concrete shall be tamped or vibrated sufficiently to eliminate all voids and to bring the mortar to the top, after which the surface shall be uniformly finished with a wood float. All edges shall be rounded with an edging tool having a 1/4-inch (6 mm) radius. After finishing, the concrete shall be cured in the same manner as required for concrete pavement except that transparent membrane shall be used in lieu of pigmented membrane.

**608.3.6** After the concrete has sufficiently set, the forms shall be removed and where necessary, the area adjacent to the concrete shall be backfilled with suitable material, compacted and finished in a satisfactory manner.

**608.3.7** During cold weather, the limitations and protection requirements of [Secs 502.4](#) and [502.4.1](#) shall apply to this work.

#### **608.4 Method of Measurement.**

**608.4.1** Measurement of concrete median and median strip will be made to the nearest 1/10 square yard (0.1 m<sup>2</sup>) or to the nearest linear foot (0.5 m) as specified in the contract. Final measurement of the completed concrete median and median strip will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**608.4.2** Concrete sidewalk will be measured to the nearest 1/10 square yard (0.1 m<sup>2</sup>).

**608.4.3** Paved approach will be measured from the beginning of the return on one side of the approach to the end of the return on the other side of the approach to the nearest 1/10 square yard (0.1 m<sup>2</sup>). Integral curb constructed on paved approaches will not be measured or paid for separately but will be included in the contract unit price for paved approaches. Final measurement of the completed paved approach will not be made except for authorized

changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**608.4.4** All excavation and all work necessary in preparing the subgrade and backfilling will be paid for as one or more of the classifications of roadway excavation. Final measurement of excavation will not be made except as set out in [Sec 203.7](#).

**608.5 Basis of Payment.**

**608.5.1** The accepted quantities of concrete steps will be paid for in the following manner:

(a) Class B concrete will be measured and paid for in accordance with [Sec 703](#) for miscellaneous concrete.

(b) Reinforcing steel will be measured and paid for in accordance with [Sec 706](#).

**608.5.2** The accepted quantities of concrete median, median strip, sidewalk and paved approach, complete in place, will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for furnishing or installing reinforcement.

## SECTION 609

### PAVED DRAINAGE

#### SECTION 609.10 CONCRETE CURB, GUTTER AND PAVED DITCH

**609.11 Description.** This work shall consist of constructing curb, gutter or combination curb and gutter and paved ditches in conformity with the lines, grades, dimensions and typical sections shown on the plans or as directed by the engineer.

**609.12 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete Structures	<a href="#">1036.1</a>
Material for Joints	<a href="#">1057.1</a>

Material, proportioning, air-entraining, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#). Concrete shall be either Class B or Pavement concrete. Concrete shall be placed, finished and cured in accordance with the applicable provisions of [Sec 703](#).

#### **609.13 Construction Requirements.**

**609.13.1** These items shall be placed on a prepared subgrade of uniform density. Forms shall be metal or sound dressed lumber, straight, free from warp, of sufficient strength to resist springing during construction and of a height equal to the full depth of the item to be constructed. Wood forms shall have a minimum nominal thickness of 2 inches (50 mm) except where flexible forms are used. Flexible forms will be required for all curved form lines, except that straight steel form sections 10 feet (3 m) long or less may be used for form lines having a radius greater than 200 feet (60 m). Straight steel form sections 5 feet (1.5 m) long will be acceptable for form lines having a radius of not less than 100 feet (30 m). The forms shall be thoroughly cleaned, well oiled, securely staked, braced and held to the required line and grade.

**609.13.1.1** In lieu of the forming requirements specified in [Sec 609.13.1](#), slip-form methods may be used for placement of concrete curb, concrete gutter, curb and gutter and paved ditch provided proper lines, grades and typical sections are maintained.

**609.13.2** Required reinforcement and tie bars shall be held in the specified position during the placing of concrete by bar chairs or other approved devices. Joints shall be constructed at intervals and locations shown on the plans or as directed by the engineer.

**609.13.3** Concrete shall be placed on the prepared and sprinkled subgrade, consolidated and struck off to the required thickness. Concrete shall be tamped or vibrated sufficiently to eliminate all voids and to bring mortar to the top, after which the surface shall be finished smooth and even. All edges shall be rounded with an edging tool having a 1/4-inch (6 mm) radius. Faces of curb shall be rounded at the top and bottom, by means of an approved tool, to the radius shown. After finishing, concrete shall be cured in the same manner as required for concrete pavement except that transparent membrane shall be used in lieu of pigmented membrane.



**609.13.4** After the concrete has set sufficiently, the forms shall be removed, and where necessary, the contractor shall backfill adjacent to the concrete with suitable material, compacted and finished in a satisfactory manner.

**609.13.5** During cold weather, the limitations and protection requirements of [Secs 502.4](#) and [502.4.1](#) shall apply to this work.

**609.14 Method of Measurement.**

**609.14.1** Curb, gutter and combination curb and gutter will be measured to the nearest linear foot (0.5 m). Measurement will be made along the curb face or along the flow line of gutters exclusive of paved approaches.

**609.14.2** Paved ditches will be measured to the nearest 1/10 square yard (0.1 m<sup>2</sup>).

**609.15 Basis of Payment.** The accepted quantities of curb, gutter, curb and gutter, and paved ditch, complete in place, will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for excavation below the upper surface of the concrete of these items nor for any work necessary for preparing the subgrade and backfilling the completed item. No direct payment will be made for furnishing or installing reinforcement.

**SECTION 609.20 INTEGRAL CURB**

**609.21 Description.** This work shall consist of curb constructed on the edge of concrete pavement in conformity with the typical section shown on the plans.

**609.22 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Material for Joints	<a href="#">1057.1</a>

Integral curb shall be constructed of concrete conforming to that required for concrete pavement except that coarse aggregate conforming to the gradation requirements of [Sec 1005.1.3](#) may be used. The quantity of coarse aggregate in the mix may be reduced to obtain better workability.

**609.23 Construction Requirements.**

**609.23.1** The curb shall be an integral part of the supporting concrete pavement and may be placed immediately after all pavement finishing operations have taken place and before the pavement has taken its initial set, or tie bars may be set in the freshly finished pavement to serve ultimately as a tie between the pavement and the curb, which may be constructed later. Neither of these methods will be required for the distance needed for paving equipment to be backed up near a construction joint. The pavement surface within this relatively short distance shall be roughened throughout the area to be covered by the curb.

**609.23.2** Metal forms joined neatly and tightly, set accurately to alignment and grade and securely held in place by connections and bracing shall be used for this work. Forms for curved form lines shall be provided in a manner similar to that required for concrete pavement in [Sec 502.3.3.1](#).

**609.23.2.1** In lieu of the forming requirements of [Sec 609.23.2](#), slip-form methods may be used for placement of integral curb provided all other requirements of [Sec 609.23](#) are met.

**609.23.3** The finished curb shall be true to line, grade and cross section, with the top and face finished smooth by means of a wood float. The top edges of the curb shall be rounded with approved edging tools. Curing shall be accomplished in the same manner as required for concrete pavement except that the use of transparent membrane will be acceptable. Joints of preformed material shall be placed through the curb and into each underlying transverse pavement joint to the full depth of the joint in the pavement. The preformed material shall extend entirely through the curb to within 1/4 inch (6 mm) of the top and face of the curb.

**609.23.4** Where the tie bars are set in the freshly finished pavement surface and membrane curing is used on the pavement, care shall be taken to avoid spraying the membrane on the protruding tie bars or the area on which the integral curb is to be placed. Another of the alternatives of [Sec 502.12](#) shall be used for curing this area of the pavement.

**609.23.5** Integral curb straightedged parallel to the centerline shall not show a variance greater than 1/4 inch (6 mm) from a 10-foot (3 m) straightedge.

**609.24 Method of Measurement.** Integral curb will be measured to the nearest linear foot (0.5 m) along the curb face, exclusive of paved approaches. Final measurement of the completed integral curb will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**609.25 Basis of Payment.** The accepted quantity of integral curb, complete in place, will be paid for at the unit price for each of the pay items included in the contract. Payment for curb constructed on paved approaches will be included in the contract unit price for paved approaches.

#### **SECTION 609.30 ASPHALT CURB**

**609.31 Description.** This work shall consist of constructing a curb of asphaltic concrete in conformity with the lines, grades and dimensions shown on the plans or established by the engineer. All applicable provisions of [Sec 403](#) shall apply to this construction.

**609.32 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

<b>Item</b>	<b>Section</b>
Coarse Aggregate	<a href="#">1002.1</a>
Fine Aggregate	<a href="#">1002.2</a>
Mineral Filler	<a href="#">1002.3</a>
Asphalt Binder, Performance Graded (PG)	<a href="#">1015</a>

**609.33 Composition of Mixture.** The asphaltic concrete mixture shall consist of aggregates, filler if needed, and asphalt binder combined in such proportions that the composition by weight (mass) of the finished mixture shall be within the limits specified for Type I-C mixture in accordance with [Sec 403.3.1](#). The contractor shall submit in writing for approval the job-mix formula the contractor proposes to use for asphalt curb. The Type I-C job-mix formula approved for asphaltic concrete pavement shall not be used for asphalt curb.

#### **609.34 Construction Requirements.**

**609.34.1** The curb shall be placed in position on a primed surface by means of an approved automatic curb machine which shapes and compacts the mixture to the specified cross section. The placement temperature of the mixture shall be approximately 260 F (125 C). All joints shall be carefully made in such manner as to ensure a continuous bond between the old and new sections of the curb.

**609.34.2** The newly laid curb shall be protected from traffic by barricades or other suitable methods until the heat of the asphalt mixture has dissipated. Immediately after the asphalt curb has hardened, it shall be backfilled where required with suitable material.

**609.34.3** If painting of the asphalt curb is specified in the contract, a light coat of commercial grade asphalt base aluminum paint shall be first applied.

**609.35 Method of Measurement.** Asphalt curb will be measured to the nearest linear foot (0.5 m).

**609.36 Basis of Payment.** The accepted quantity of asphalt curb will be paid for at the contract unit price. No direct payment will be made for priming prior to placing of the curb or for painting the completed curb.

#### **SECTION 609.40 DRAIN BASIN**

**609.41 Description.** This work shall consist of furnishing and constructing a drain basin in conformity with details shown on the plans or as directed by the engineer.

##### **609.42 Material.**

**609.42.1** Drain basins shall consist of a drop inlet of a size and type shown on the plans, grates and bearing plates for drop inlet, corrugated metal pipe with size as shown on plans and rock ditch lining at corrugated metal pipe outlet as shown on plans. These items shall meet the requirements of the following specifications:

<b>Item</b>	<b>Section</b>
Rock Ditch Lining	<a href="#">609.70</a>
Grates and Bearing Plates	<a href="#">614</a>
Corrugated Metal Pipe	<a href="#">1020</a>
Drop Inlet	<a href="#">1033</a>

##### **609.43 Construction Requirements.**

**609.43.1** The excavating and backfilling shall be in accordance with the applicable portions of [Secs 604](#) and [725](#). The adjustment shall be made to the line and grade shown on the plans or as directed by the engineer.

**609.43.2** The rock lining for drain basin outlet ditch shall be placed to the limits shown on the plans or as directed by the engineer.

**609.43.3** The concrete slope protection for the drain basin outlet shall be placed as shown on the plans or as directed by the engineer.

**609.44 Basis of Payment.** The accepted drain basin complete in place will be paid for at the contract unit price per each. Payment for concrete slope protection required for drain basins will be paid for at the contract unit price per square yard (square meter). The accepted

quantities of Class 3 excavation required for installing drain basin will be paid for at the contract unit price.

## **SECTION 609.50 BLANK**

## **SECTION 609.60 DITCH LINER**

**609.61 Description.** This work shall consist of constructing ditch liner at the locations shown on the plans or as directed by the engineer.

**609.62 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows: Concrete shall be Class B or B-1, or concrete of a commercial mixture meeting the requirements of [Sec 501.14](#). Placement of concrete by pumping equipment acceptable to the engineer will be permitted. To facilitate pumping, an increase in the percent of fine aggregate will be allowed. Grout shall meet the requirements of [Sec 611.22.3](#). Placement of grout by pumping equipment acceptable to the engineer will be permitted. Rock material shall be durable stone or broken concrete free of any coating of soil. Acceptance of rock material may be made by visual inspection at the job site.

### **609.63 Construction Requirements.**

**609.63.1** Ditch liners shall be constructed by either placing concrete directly on the prepared subgrade or by placing rock directly on the prepared subgrade followed by the application of grout. Use of the grouted rock method shall be limited to grades of 6 percent or less. The grout shall have a consistency permitting it to flow readily into the voids.

**609.63.2** The ditch liner shall be placed to the thickness shown on the plans on a subgrade of reasonably uniform density.

**609.63.3** Forms will not be required. Concrete shall be consolidated and struck off to the required thickness and shape.

**609.63.4** Weather limitations and protection requirements of [Secs 502.4](#) and [502.4.1](#) shall apply to placing of concrete and grout.

**609.63.5** Concrete and grout shall be cured in the same manner as required for concrete pavement except that transparent membrane may be used in lieu of pigmented membrane.

**609.63.6** After the concrete or grout has set sufficiently, any forms shall be removed. The contractor shall, where necessary, backfill adjacent to the ditch liner with suitable material, compacted and finished in a satisfactory manner.

**609.64 Method of Measurement.** Ditch liner will be measured to the nearest square yard (square meter) of surface.

**609.65 Basis of Payment.** The accepted quantity of ditch liner, complete in place, will be paid for at the contract unit price. No direct payment will be made for excavation below the upper surface of the ditch liner, nor for any work necessary for preparing the subgrade and backfilling the completed item.

## **SECTION 609.70 ROCK LINING**

**609.71 Description.** This work shall consist of constructing rock lining at the locations shown on the plans or as directed by the engineer.

**609.72 Material.** The material for rock lining shall meet the requirements of [Sec 611.30](#) for Type 2 rock blanket.

**609.73 Construction Requirements.** The rock lining material shall be placed by dumping and left in a rough condition to the approximate shape of the channel bottom.

**609.74 Method of Measurement.** Measurement will be made to the nearest cubic yard (cubic meter) of material in place in the completed rock lining. Final measurement of the completed rock lining will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**609.75 Basis of Payment.** The accepted quantity of rock lining in place will be paid for at the contract unit price. No direct payment will be made for any excavation required to place the rock lining.

## SECTION 610

### MASONRY CONSTRUCTION

#### SECTION 610.10 RUBBLE MASONRY

**610.11 Description.** This work shall consist of stone laid in mortar or laid dry as specified in the contract, and in conformity with the lines and grades shown on the plans or as established by the engineer.

**610.12 Material.** Stone for rubble masonry shall be sound and durable, and relatively free of shale or other easily disintegrated material. In general, the stone shall not be less than 4 inches (100 mm) thick, however an occasional stone not less than 2 inches (50 mm) thick will be permitted. The stones shall not be less than 12 inches (300 mm) wide, and shall be from 12 to 36 inches (300 to 900 mm) long. The width shall not be less than the thickness, nor shall the length exceed three times the thickness. The stones shall be roughly squared on joints, beds and faces. Selected stone shall be used for the ends and angles of walls. Mortar for joints shall meet the requirements of [Sec 1066.1.3](#). Precast concrete blocks may be substituted for stone for masonry. Such blocks shall be of the size specified above, and shall be made of either Class B concrete or concrete of a commercial mixture meeting the requirements of [Sec 501.14](#). Concrete shall be proportioned, mixed and transported in accordance with [Sec 501](#), and shall be cured by any of the methods specified for concrete pavement, except that transparent membrane shall be used in lieu of pigmented membrane. For dry rubble masonry, the contractor may use broken concrete in lieu of stone, if approved by the engineer. The pieces of broken concrete shall be of the size specified above.

#### **610.13 Construction Requirements.**

**610.13.1 Rubble Masonry Laid in Mortar.** All stone or blocks shall be thoroughly wetted and laid upon their natural beds with joints approximately horizontal and vertical. Each stone or block shall be settled into place in a full bed of mortar. In general, the wall shall be laid with face joints not exceeding 1 1/2 inches (40 mm) in thickness and with vertical joints broken not less than 6 inches (150 mm). The vertical joints in the interior of the wall shall be filled with suitable stone or spalls thoroughly bedded in mortar. Voids will not be permitted. Headers shall be arranged to occupy at least 1/4 the area of the face and back, and shall be evenly distributed. For walls 2 feet (600 mm) thick or less, headers shall extend entirely through the wall. For thicker walls, front, back and intermediate headers shall be arranged to lap at least 12 inches (300 mm).

**610.13.1.1** All joints on the exposed faces shall be raked out to a depth of approximately 1 1/2 inches (40 mm) and shall be thoroughly wetted. They shall then be filled flush with mortar pressed tightly into place with suitable tools, and cured with transparent curing membrane.

**610.13.1.2** During cold weather, the limitations and protection requirements of [Secs 502.4](#) and [502.4.1](#) shall apply to the grout and concrete.

**610.13.2 Rubble Masonry Laid Dry.** Dry rubble masonry shall be built with broken joints and placed in a manner forming a solid self-supporting wall. After the stone has been placed, the voids shall be filled with spalls or small stones so that all stones are tightly wedged or keyed. The finished wall shall have a uniform surface.

**610.13.3** Excavation for rubble masonry shall be of sufficient width and depth to permit the proper placing of the stones on a firm, solid foundation or footing. Backfilling shall be done to the finished ground line with suitable material placed in layers, and each layer firmly compacted into place.

**610.14 Method of Measurement.** Measurement will be made to the nearest 1/10 cubic yard (0.1 m<sup>3</sup>) in accordance with the dimensions shown on the plans or as revised by the engineer during construction. Copings and footings will generally be made of concrete and will be measured and paid for as concrete masonry. Excavating and backfilling will be measured and paid for as Class 3 Excavation in accordance with the requirements of [Sec 206](#).

**610.15 Basis of Payment.** The accepted quantity of rubble masonry will be paid for at the unit price for each of the pay items included in the contract.

## **SECTION 610.20 BRICK MASONRY**

**610.21 Description.** This work shall consist of brick laid in a mortar bed in conformity with the lines, grades and dimensions shown on the plans or as directed by the engineer.

### **610.22 Material.**

**610.22.1** Sewer brick shall meet the requirements of AASHTO M 91 and shall be Grade MM or Grade SM as specified in the contract.

**610.22.2** Mortar shall meet the requirements of [Sec 1066.1.3](#).

**610.23 Construction Requirements.** Brick shall be thoroughly wetted and laid with full mortared vertical and horizontal joints. The work shall be constructed with sufficient header courses to tie the brick masonry together. Full mortar beds shall be provided for setting any proposed castings, and the castings shall be set to the required elevation. Brick masonry around pipe or tile shall be carefully constructed to provide watertight connections. Masonry shall not be laid in freezing weather without the use of such precautions as the engineer may approve.

**610.24 Method of Measurement.** Measurement will be made to the nearest cubic foot (0.1 m<sup>3</sup>). Any concrete masonry in connection with brick masonry will be measured and paid for as concrete masonry.

**610.25 Basis of Payment.** The accepted quantity of brick masonry will be paid for at the contract unit price.

## SECTION 611

### EMBANKMENT PROTECTION

#### SECTION 611.10 ROCK FILL

**611.11 Description.** This work shall consist of constructing fill of rock or broken concrete for protection of embankment.

**611.12 Material.** The material for rock fill shall be durable stone or broken concrete containing a combined total of not more than 10 percent of earth, sand, shale and non-durable rock. It is intended that the material be similar to quarry-run stone graded from coarse to fine with a minimum of voids. The coarse stone shall be as large as can be conveniently handled, but at least 25 percent of the material shall be of pieces having a volume of one cubic foot (0.03 m<sup>3</sup>) or more. Acceptance of quality and size of material may be made by visual inspection at the job site.

**611.13 Construction Requirements.** Successive horizontal layers of stone or broken concrete not exceeding 24 inches (600 mm) thick shall be spread over the area of the rock fill. The larger pieces shall be well distributed and the interstices filled with smaller pieces. Each layer shall be spread in accordance with the methods specified in [Sec 203.2.18](#). Where rock fill is placed as a portion of embankment with controlled density, the material shall be compacted in accordance with the requirements of [Sec 203.3.5](#). The fill shall conform to the elevations and dimensions shown on the plans, and the slopes shall present a dense, finished appearance free from segregation and with a proportionate quantity of the large pieces showing.

**611.14 Method of Measurement.** Measurement will be made to the nearest cubic yard (cubic meter) of material in place in the completed fill.

#### **611.15 Basis of Payment.**

**611.15.1** If shown on the plans that the material for rock fill is to be obtained from the right of way or other source furnished by the Commission, the excavating, together with all breaking, loading and hauling, regardless of distance to the site of the rock fill, will be paid for and considered completely covered under such contract items as Class A Excavation, Class C Excavation, Unclassified Excavation, Excavation for Structures or other applicable items. If payment is made under these conditions, separate payment for furnishing rock fill will not be made.

**611.15.1.1** If the plans show material for rock fill to be secured from such sources and this material is made unsuitable or unattainable by the contractor's operations, the contractor shall provide suitable material and dispose of any surplus material, at no additional cost to the Commission.

**611.15.1.2** If the plans provide for obtaining material from the right of way or other source furnished by the Commission, but all or part of the required quantity of acceptable material is not actually available, payment will be made at the unit price of \$15.00 per cubic yard (\$19.60/m<sup>3</sup>) for such additional rock fill material that the contractor is required to furnish and haul.



**611.15.2** If the plans do not provide for a source of material, the contractor shall provide the material, and all costs of securing the source, quarrying, excavating, breaking and hauling the material to the site will be paid for and completely covered by the contract unit price per cubic yard (cubic meter) for furnishing rock fill.

**611.15.3** Payment for placing rock fill will be made at the contract unit price per cubic yard (cubic meter).

#### **SECTION 611.20 FULLY GROUTED ROCK FILL**

**611.21 Description.** This work shall consist of furnishing and constructing a fully grouted rock fill as shown on the plans, or as directed by the engineer.

#### **611.22 Material.**

**611.22.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Cement	<a href="#">1019</a>

**611.22.2** The stone or broken concrete for rock fill shall meet the requirements of [Sec 611.12](#).

**611.22.3** Grout shall consist of one part portland cement and 5 parts of aggregate by volume. Approved Class C or F fly ash may be used to replace a maximum of 15 percent of portland cement on a pound for pound (kilogram for kilogram) basis. The aggregate shall be a mixture of clean sand and gravel, or of crushed stone and sand, or of chat and sand, all of approved quality. The mixture shall be uniformly graded from coarse to fine and meet the following gradation requirements:

	Percent
Passing 3/4-inch (19.0 mm) sieve	100
Passing No. 4 (4.75 mm) sieve	40 to 60

Finer aggregate may be used provided the ratio of cement to the material passing the No. 4 (4.75 mm) sieve is not greater than one to three by volume.

#### **611.23 Construction Requirements.**

**611.23.1** The rock and grout shall be placed in a manner resulting in a securely bound solid mass with the interstices completely filled. The grout shall have a consistency permitting it to flow readily into the voids. After the interstices have been completely filled with grout, the surface shall be swept clean of all surplus grout with a stiff broom and cured by any one of the methods specified for concrete pavement, except that transparent membrane shall be used in lieu of pigmented membrane.

**611.23.2** During cold weather, the limitations and the protection requirements of [Secs 502.4](#) and [502.4.1](#) shall apply to the grouting.

**611.24 Method of Measurement.** Measurement of fully grouted rock fill will be made to the nearest 1/2 cubic yard (0.5 m<sup>3</sup>) complete in place.

**611.25 Basis of Payment.** The accepted quantity of fully grouted rock fill will be paid for at the contract unit price. No direct payment will be made for furnishing or placing the rock fill.

### **SECTION 611.30 ROCK BLANKET**

**611.31 Description.** This work shall consist of constructing a protecting blanket of rock or broken concrete on slopes or stream banks.

**611.32 Material.** The material for rock blanket shall be durable stone or broken concrete containing a combined total of not more than 10 percent of earth, sand, shale and non-durable rock. It is preferable that the material contain a large percentage of pieces as large as the thickness of the blanket will permit, with enough smaller pieces of various sizes to fill the larger voids. For Type 1 Rock Blanket, at least 40 percent of the mass shall be of pieces having a volume of one cubic foot (0.03 m<sup>3</sup>) or more. For Type 2 Rock Blanket, at least 60 percent of the mass shall be of pieces having a volume of one cubic foot (0.03 m<sup>3</sup>) or more. Acceptance of quality and size of material may be made by visual inspection at the job site.

**611.33 Construction Requirements.** A trench at the toe of the slope shall be excavated to the elevation as shown on the plans, or to a depth of 2 feet (600 mm) if not shown. The slopes shall conform to the proper cross section and be compacted to a uniform density as required for adjacent material. The rock or broken concrete shall be placed on the slope, to the specified thickness, elevation and extent, and manipulated so that most of the flat sides are in contact, thereby eliminating large voids. The finished surface of the blanket shall present an appearance free from segregation and with a proportionate quantity of the larger pieces showing.

**611.34 Method of Measurement.** Measurement will be made to the nearest cubic yard (cubic meter) of material in place in the completed blanket.

### **611.35 Basis of Payment.**

**611.35.1** If shown on the plans that the material for rock blanket is to be obtained from the right of way or other source furnished by the Commission, the excavating, together with all breaking, loading and hauling, regardless of distance to the site of the rock blanket, will be paid for and considered completely covered under such contract items as Class A Excavation, Class C Excavation, Unclassified Excavation, Excavation for Structures or other applicable items. If payment is made under these conditions, separate payment for furnishing rock blanket will not be made.

**611.35.1.1** If the plans show material for rock blanket to be secured from such sources and this material is made unsuitable or unattainable by the contractor's operations, the contractor shall provide suitable material and dispose of any surplus material, at no additional cost to the Commission.

**611.35.1.2** If the plans provide for obtaining material from the right of way or other source furnished by the Commission, but all or part of the required quantity of acceptable material is not actually available, payment will be made under [Sec 109.4](#) for the purchase and delivery of any additional rock blanket material that is required.

**611.35.2** If the plans do not provide for a source of the material, the contractor shall provide the material and all costs of securing the source, quarrying, excavating, breaking and hauling the material to the site will be paid for and completely covered by the contract unit price per cubic yard (cubic meter) for furnishing rock blanket. However, if material suitable for rock blanket is encountered within the limits of the right of way or other sources furnished by the

Commission, and the material is used in the construction of the rock blanket, then payment will be made in accordance with [Sec 611.35.1](#).

**611.35.3** Payment for placing rock blanket will be made at the contract unit price per cubic yard (cubic meter). No direct payment will be made for excavating the trench or for backfilling.

#### **SECTION 611.40 GROUTED ROCK SURFACE**

**611.41 Description.** This work shall consist of surface grouting rock fill or rock blanket as shown on the plans or as directed by the engineer.

**611.42 Material.** Grout shall meet the requirements of [Sec 611.22.3](#) and have a consistency thin enough to permit thorough penetration of the grout into the joints and voids between the stones.

#### **611.43 Construction Requirements.**

**611.43.1** After completion of the rock fill or rock blanket in accordance with [Sec 611.10](#) or [611.30](#), whichever is applicable, the surface shall be grouted at the rate of a one sack batch of grout to 2 square yards ( $0.075 \text{ m}^3/\text{m}^2$ ) of surface covered except that if the finer aggregate is used, a one sack batch shall cover approximately 1 1/2 square yards ( $0.1 \text{ m}^3/\text{m}^2$ ) shall be used. The surface shall be swept clean of surplus grout with a stiff broom, using the major portion of the grout to fill the voids between the stones. The grout shall be cured by any of the methods specified for concrete pavement, except that transparent membrane shall be used in lieu of pigmented membrane.

**611.43.2** During cold weather, the limitations and protection requirements of [Secs 502.4](#) and [502.4.1](#) shall apply to the grouting.

**611.44 Method of Measurement.** Measurement will be made to the nearest square yard (square meter) of grouted surface completed.

**611.45 Basis of Payment.** The accepted quantity of grouted rock surface will be paid for at the contract unit price.

#### **SECTION 611.50 REVETMENT**

**611.51 Description.** This work shall consist of slope or bank protection constructed at locations shown on the plans or as directed by the engineer and shall be of the type or types included in the contract.

**611.52 Material.** Acceptance of quality and size of material may be made by visual inspection at the job site.

**611.52.1** Stone for light stone revetment shall be sound, durable and free from cracks and other structural defects that would cause it to deteriorate. It shall not contain any soapstone, shale, or other material easily disintegrated. The stone shall be in blocks at least 7 inches (180 mm) thick perpendicular to the slope and have approximately rectangular faces 7 inches (180 mm) wide or more. All blocks shall weigh (have a mass of) not less than 25 pounds (10 kg), and at least 75 percent shall weigh (have a mass of) not less than 50 pounds (20 kg).

**611.52.2** The stone for heavy stone revetment shall conform to the requirements of [Sec 611.52.1](#), except that the blocks shall be at least 12 inches (300 mm) thick perpendicular to the

slope and all blocks shall weigh (have a mass of) not less than 50 pounds (20 kg) and at least 60 percent shall weigh (have a mass of) not less than 100 pounds (40 kg).

**611.52.3 Concrete Blocks.** At the contractor's option, concrete blocks may be substituted for stone, provided the concrete blocks conform to the requirements for size and weight (mass) as specified for stone. The blocks shall be made of either Class B concrete or concrete of a commercial mixture meeting the requirements of [Sec 501.14](#). Concrete shall be proportioned, mixed and transported in accordance with [Sec 501](#), and shall be cured by any of the methods specified for concrete pavement, except that transparent membrane shall be used in lieu of pigmented membrane. Blocks may be precast and then laid in the required location or they may be cast in place on the slope, provided joints are spaced so that they will completely sever the concrete into blocks not larger than 2 x 4 feet (600 x 1200 mm) with the long dimension horizontal and with vertical joints broken.

**611.52.4 Broken Concrete.** If other work included in the contract requires quantities of broken concrete, the contractor may use such material as blocks for revetment, provided minimum size and weight requirements for stone are maintained.

**611.52.5 Grout.** Grout for grouted revetment shall be composed of one part cement and three parts approved clean sand, by volume, and shall have a consistency which will permit it to flow readily into the joints. Grout shall be used within 30 minutes after water has been added.

### **611.53 Construction Requirements.**

**611.53.1** Unless otherwise approved, the slopes upon which revetment is to be placed shall conform to the section shown on the plans. The slopes shall be compacted to a uniform density as required for adjacent material. The revetment shall be started in a trench below the toe of the slope shown on the plans and shall progress upward. Each stone or block shall be laid perpendicular to the slope, shall be firmly bedded against the slope and against adjoining stones or blocks and shall be laid with well broken joints. Only one layer of stone or blocks perpendicular to the slope will be permitted. After revetment has been placed, the voids shall be filled with spalls or small stone in such manner that all revetment stones or blocks are tightly wedged. The finished surface shall present a uniform appearance true to line, grade and section.

**611.53.2** If specified in the contract, revetment shall be surface grouted. Grout shall be applied in such manner as to ensure filling all joints and crevices and shall be cured by any of the methods specified for concrete pavement, except that transparent membrane shall be used in lieu of pigmented membrane.

**611.53.2.1** If precast concrete blocks are substituted for stone in revetment designated for grouted surface, the blocks shall be placed with joints wide enough to accept grout for the full depth of the joint.

**611.53.2.2** If cast in place concrete blocks are substituted for stone in revetment designated for grouted surface, the blocks shall be formed and cast in such a manner that there will be no open joints and grouting will not be required.

**611.53.3** During cold weather, the limitations and protection requirements of [Secs 502.4](#) and [502.4.1](#) shall apply to the grout and concrete.

**611.54 Method of Measurement.** Measurement will be made to the nearest 1/10 square yard (0.1 m<sup>2</sup>).

**611.55 Basis of Payment.** The accepted quantity of revetment will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for excavating the trench or for any backfilling required.

## **SECTION 611.60 CONCRETE SLOPE PROTECTION**

**611.61 Description.** This work shall consist of constructing a concrete slope protection by placing concrete on the finished earth slope, in conformity with the lines and grades shown on the plans.

**611.62 Material.** Slope protection shall be of Class B concrete, with material, proportioning, mixing, slump and transporting of concrete conforming to [Sec 501](#). Concrete shall be placed, finished and cured in accordance with the applicable provisions of [Sec 703](#).

### **611.63 Construction Requirements.**

**611.63.1** The concrete shall be placed on a prepared, compacted subgrade of uniform density, and shall be consolidated and struck off to the required thickness. Joints shall be the full depth of the concrete and shall consist of material conforming to [Sec 1057.1.4](#).

**611.63.2** The surface of the paved slope shall have a broom or burlap drag finish and shall be cured in the same manner as required for concrete pavement, except that transparent membrane shall be used in lieu of pigmented membrane.

**611.63.3** During cold weather, the limitations and protection requirements of [Secs 502.4](#) and [502.4.1](#) shall apply to this work.

**611.64 Method of Measurement.** Measurement will be made to the nearest 1/10 square yard (0.1 m<sup>2</sup>).

**611.65 Basis of Payment.** The accepted quantity of concrete slope protection will be paid for at the contract unit price. No direct payment will be made for any excavating or for other work necessary in preparing the subgrade or for any backfilling required.

## **SECTION 611.70 GABIONS**

**611.71 Description.** This work shall consist of installing gabions at locations shown on the plans or as directed by the engineer and shall be the size included in the contract.

### **611.72 Materials.**

**611.72.1** The gabion baskets shall be made of hexagonal triple twist or welded galvanized steel wire mesh.

**611.72.2** The maximum linear dimension of the mesh opening shall not exceed 4 1/2 inches (115 mm). The area of the mesh opening shall not exceed 10 square inches (6500 mm<sup>2</sup>). Gabions shall be supplied, as specified, in various lengths and heights. The lengths shall be 6, 9 or 12 feet (1.8, 2.7 or 3.6 m) as required. The horizontal width shall be 3 feet (900 mm). Dimensions for heights, lengths and widths are subject to a tolerance limit of plus or minus three percent of the manufacturer's stated sizes.

**611.72.3** All steel wire used in the gabions shall meet the requirements of ASTM A 641. The mesh steel wire diameter for gabions shall not be less than 0.1181 inches, U.S. Gauge No. 11 (3 mm), and the mesh edge wire and selvage wire of hexagonal triple twist gabions shall not

be less than 0.1535 inches, U.S. Gauge No. 9 (3.9 mm). The lacing steel wire for binding the gabion units together shall not be less than 0.0866 inches, U.S. Gauge No. 13.5 (2.2 mm). All welds shall have minimum shear strength of 600 psi (2.7 kN).

**611.72.4** All steel wire used in the gabions shall be galvanized with a zinc coating. Zinc galvanizing shall not be less than 0.80 ounces per square foot (0.24 kg/m<sup>2</sup>). The test specimen size and method of tests for determining the weight (mass) of coating shall be in accordance with AASHTO T 65. At the option of the engineer, material may be accepted on the basis of magnetic gauge determinations made in accordance with ASTM E 376 or upon the manufacturer's certification.

**611.72.5** When the length of the gabion exceeds 4 feet (1.2 m), the gabion shall be divided by diaphragms, of the same mesh and gauge as the body of the gabions, into cells of equal length and width. The gabion shall be furnished with the necessary diaphragms secured in proper position on the base in such a manner that no additional tying at this juncture will be necessary.

**611.72.6** Rock used in the gabions shall be crushed limestone. The crushed limestone shall be 10 inch (250 mm) maximum size and a 4 inch (100 mm) minimum size.

**611.73 Construction Requirements.**

**611.73.1** The contractor shall follow the manufacturer's recommended procedure for installation.

**611.73.2** Cut compaction shall be performed in all Class A material areas where the baskets are constructed. The exposed material, to a depth of 6 inches (150 mm), shall be manipulated and compacted to not less than the required density. The material above this compacted plane shall be spread in layers, each being wetted or dried as necessary and compacted to the specified density. The entire volume of materials so handled and compacted, including the 6-inch (150 mm) layer compacted in place, will be considered as Compacting in Cut. All Class A material having a liquid limit of 40 or more, including the 6-inch (150 mm) layer compacted in place, shall be compacted at not less than optimum moisture content.

**611.73.3** Excavated material beyond the limits of the baskets shall be backfilled with gravel or crushed rock material meeting the approval of the engineer.

**611.74 Method of Measurement.**

**611.74.1** The pay limits for excavation for gabions will be a line coincidental with the bottom and non-exposed side of the baskets. Excavation quantities will be determined from the cross sections and paid for under the appropriate classified excavation items and be made to the nearest cubic yard (cubic meter).

**611.74.2** Measurement of gabions will be made to the nearest cubic yard (cubic meter).

**611.75 Basis of Payment.**

**611.75.1** The quantity to be paid for gabions will be the number of cubic yards (cubic meters) of gabions measured in their final position. Job conditions and availability will determine the actual size baskets to be used. Any costs that might occur will be included and paid for in the cost per cubic yard (cubic meter) of gabions.

**611.75.2** Payment for gabions will be made at the contract unit price per cubic yard (cubic meter) and will be full compensation for all labor, equipment and materials to complete the described work.

## SECTION 612

### BARRICADES AND FLASHER SIGNS

**612.1 Description.** This work shall consist of constructing and maintaining wood fences in accordance with the plans for (1) temporary barricade, with double or single gates, (2) permanent barricade and (3) movable barricade. This work shall also consist of constructing and maintaining flasher signs in accordance with the plans.

**612.2 Material.** Lumber for barricades and signboards shall be well seasoned, straight and free from serious defects which will materially impair the strength. Posts used for permanent barricades shall be liberally treated with two coats of commercially available creosote or pentachlorophenol solution. The second coat shall be applied after the first coat has been absorbed. Paint for barricades shall be a good quality, commercially available product. Reflective sheeting shall meet the requirements of [Sec 1042.2.7.1](#).

#### **612.3 Construction Requirements.**

**612.3.1 Barricades.** Barricades shall be constructed at locations shown on the plans or as directed by the engineer. The contractor shall provide warning reflectors on the barricades, and shall maintain the reflectors, barricades and signboards in good condition throughout the duration of the contract.

**612.3.1.1 Painting and Striping.** The surfaces of all wood barricades shall be given a prime coat and a finish coat of white paint, except that portion that is treated with preservative. The surfaces of horizontal boards and panels for all types of barricades that face traffic and extend across the roadbed shall be striped in accordance with the plans. The striping of all barricades shall be provided by the use of reflective sheeting applied by means of an adhesive. Colors, widths and configurations of stripes shall be as shown on the plans.

**612.3.1.2** Temporary barricades shall be built with a double gate, and the length of each barricade shall be sufficient to exclude traffic. The contractor shall provide suitable means of entrance through the barricades for persons living within the closed sections of the road who must use the roadway. Temporary barricades shall be relocated if shown on the plans or as directed by the engineer. Any material that is damaged or becomes defective during the process of moving the barricade shall be replaced. Temporary barricades shall become the property of the contractor after their use is no longer required on the project.

**612.3.1.3** Movable barricades shall be used as directed and shall become the property of the contractor after their use is no longer required on the project, unless otherwise specified in the contract. Barricades that are to become the property of the Commission shall be left in good condition with respect to repair and paint. Movable barricades that are to become the property of the Commission and those used to support flasher signs shall be constructed as shown on the plans. Movable barricades which are to become the property of the contractor may have alternate supporting frames if approved by the engineer. The alternate frames shall be of such design as to securely hold the horizontal boards in the designated position.

**612.3.1.4** Permanent barricades shall become the property of the Commission after the acceptance of the project, and shall be left in good condition with respect to repair and paint.

**612.3.2 Flasher Signs.** Flasher signs shall be provided at locations shown on the plans or as specified by the engineer. The sign shall be constructed of 3/4 or 5/8-inch (19 or 16 mm), 5-



ply, high density type overlaid Douglas Fir plywood. The sign shall be given a prime coat and a finish coat of white paint. The background for the arrow shall be provided by the use of reflective sheeting applied by means of an adhesive. Colors, widths and configurations shall be as shown on the plans. The arrow shall be painted black. Unless otherwise specified in the contract, flasher signs shall become the property of the contractor after their use is no longer required on the project. Flasher signs that are to become the property of the Commission shall be left in good condition with respect to repair and paint.

**612.3.2.1** The flasher unit shall consist of a weathertight, self-contained assembly of unit construction type consisting of an 8-inch (200 mm) yellow optical unit with tunnel visor, mounting attachments and other appurtenances. The flashing mechanism shall be controlled by either a synchronous motor or solid state circuitry operated by 110 to 120 VAC. The flashing indications shall be between 50 and 60 flashes per minute with approximately 50 percent on and off periods. The flasher unit shall provide full face illumination and shall be of an intensity which may easily be seen without producing a glare interfering with the visibility of the sign proper. The contractor shall, at no cost to the Commission, provide all necessary connections to a satisfactory power source for the operation of the flasher unit. Flasher signs that are to become the property of the Commission, shall be connected to a permanent power supply.

#### **612.4 Basis of Payment.**

**612.4.1** The accepted quantities of temporary, movable and permanent barricades will be paid for at the unit price for each of the pay items included in the contract.

**612.4.2** The accepted quantity of flasher signs, complete in place, including the cost of power for operation until acceptance of the project will be paid for at the contract unit price. Separate payment will be made for movable barricades required for flasher signs.

**612.4.3** Payment for each relocation of temporary barricades will be completely covered by the contract unit price and will include all labor and material necessary for the relocation.

**612.4.4** Payment for each relocation of flasher signs will be completely covered by the contract unit price and will include all labor and material necessary for the relocation, and power for operation until acceptance of the project.

**612.4.5** No direct payment will be made for relocating movable barricades.

## SECTION 613

### PAVEMENT REPAIR

#### 613.1 Description.

**613.1.1** Full depth pavement repair shall consist of removing specified areas of existing variable thickness portland cement concrete and replacing with reinforced portland cement concrete as shown on the plans.

**613.1.2** Partial depth pavement repair shall consist of removal of areas of unsound concrete, not to exceed 4 inches (100 mm) deep, and replacing with a bituminous mixture.

#### 613.2 Construction Requirements.

**613.2.1** Approximate locations and areas of pavement sections to be removed will be shown on the plans. Specific locations and areas shall be as specified by the engineer. All pavement repair subsequent to sawing of pavement shall be accomplished in the same day.

**613.2.2** Specified areas of full depth pavement repair shall be removed in accordance with the applicable requirements of [Sec 202.20](#) except that the saw cut shall be full depth, a diamond saw shall be used for perimeter cuts and a rock saw may be used to make a cut through the middle portion of the area to be removed for stress relief. The full depth of the pavement shall be removed without mechanically breaking in place and with a minimum disturbance of sound base. Any aggregate base disturbed by the contractor shall be recompact or removed and backfilled with portland cement concrete as an integral part of the repair. Unstable base aggregate shall be removed and replaced in accordance with [Sec 304](#), as directed by the engineer. Subgrade compaction in accordance with [Sec 210](#) shall be performed if directed by the engineer in areas of unstable subgrade, or the unstable subgrade may be removed and replaced with aggregate base material in accordance with [Sec 304](#) at the contractor's option. If subgrade compaction is performed, the aggregate base shall be replaced. Compaction shall be to the satisfaction of the engineer and inspection shall be made visually.

**613.2.3** Areas of full depth repair shall be filled with reinforced portland cement concrete as specified in the plans. Dowels and dowel holes shall be as shown on the plans. The dowel holes shall be drilled 1 3/8 inches (35 mm) in diameter maximum, to the depth shown on the plans. Equipment designed to drill multiple holes simultaneously will only be allowed provided such equipment causes no damage to existing pavement. The holes shall be blown clean and allowed to dry. The holes shall be injected with an epoxy or polyester bonding agent meeting the requirements of [Sec 1039.3](#) to fill the void around the dowel. If the bonding agent is either in bulk or cartridge form, it shall be thoroughly mixed in the proper ratio by an automatic mixing unit prior to injection into the dowel holes. The automatic mixing unit shall be an integral part of the injection device. The bonding agent shall be injected into the dowel hole by inserting the injection device to the back of the hole and slowly withdrawing the device while dispensing sufficient material to completely fill the void around the dowel when the dowel is inserted. Dowel bars shall be 1 1/4 by 18 inches (32 x 450 mm) and epoxy coated. Prior to inserting the dowel into the hole, a thin plastic disk, manufactured to slip tightly over the dowel, shall be placed over the dowel at approximately midpoint to prevent the bonding agent from flowing from the hole during placement of the dowel and to create an effective face at the entrance of the dowel hole. The dowel shall be inserted into the hole with a twisting motion so the material in the back of the hole is forced up and around the dowel. The dowel shall be placed parallel to the surface and the centerline of the traveled way and

shall not vary more than 1/4 inch (6 mm) in alignment. Dowels shall be firmly seated prior to placing concrete. Welded wire fabric shall be used and placed 3 inches (75 mm) plus or minus 1/2 inch (13 mm) below the surface of the concrete patch.

**613.2.4** Areas of partial depth concrete repair shall be sawed around the perimeter of the deteriorated area 2 inches (50 mm) deep, squaring up the area. The area shall be cleaned to remove loose material, provide a relatively uniform depth, and to provide a relatively vertical edge. Loose material shall be removed with minimal use of a maximum 15 pound (7 kg) chipping hammer or other light chipping tools and a light air blast, leaving tightly bound material in place to the satisfaction of the engineer. The area shall be a minimum of 2 inches (50 mm) in depth. Areas of less than 1 square foot (0.1 m<sup>2</sup>) are not required to be sawed, provided they can be prepared to the satisfaction of the engineer. Areas deeper than 4 inches (100 mm) or areas which indicate pumping or other movement of the subbase or structural pavement failure shall be completely removed, repaired and paid for as required for full depth concrete repairs.

**613.2.4.1** The repair area shall be suitably primed on the sides and bottom to ensure bonding of any remaining loose material as well as bonding of the repair material, however there shall not be any ponding of prime liquid at the time the area is filled. The repair area shall be filled with an approved [Sec 403](#) surface mixture meeting temperature placement requirements and thoroughly compacted over the entire repair area to density as approved by the engineer. Areas greater than 2 inches (50 mm) in depth shall be filled in two lifts, each thoroughly compacted. Re-establishing of joints by sawing is not required.

**613.2.5** Repairs shall be made to only one lane at a time. The removed concrete and any excavated subgrade material shall be disposed of at a location furnished by the contractor or at locations on the right of way approved by the engineer. If the material is disposed of outside the right of way, an acceptable written agreement with the property owner on whose property the material is placed shall be submitted by the contractor.

**613.2.6** If the repaired area is not to be resurfaced, the overcut from the sawing operation shall be filled with an expansive mortar, epoxy, polyester or joint material as directed by the engineer.

**613.2.7** All material, proportioning, air-entraining, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#) as applicable to pavement concrete, except the minimum cement requirement shall be 8 1/2 sacks per cubic yard (475 kg/m<sup>3</sup>) regardless of aggregate gradation and the maximum slump shall be 3 1/2 inches (90 mm). When Gradation F is specified, Gradation D or E may be used. All repaired areas shall be finished to provide a smooth ride and to the satisfaction of the engineer. Repaired areas shall be checked by stringline if required by the engineer. When stringlined, the surface of the repaired area shall not vary more than 1/8 inch (3 mm) per 10 feet (3 m) regardless of whether the repair is to be resurfaced or not, from a straight line between the surface of the existing pavement on each side of the repaired area. Immediately after finishing and as soon as marring of the concrete will not occur, the entire surface of the newly placed concrete shall be cured in accordance with one of the following methods. If the existing pavement has been or is to be resurfaced, an asphalt emulsion shall be applied at a rate of 0.1 gallon per square yard (0.50 L/m<sup>2</sup>), or as directed by the engineer. If the existing pavement surface is concrete and is not to be resurfaced, the curing shall be in accordance with [Sec 502](#). The area shall not be opened to traffic until the concrete has attained a minimum compressive strength of 3500 pounds per square inch (24 MPa) determined by tests made in accordance with MoDOT methods.

**613.2.7.1** When the repair is to be made and opened to traffic the same day, the concrete shall contain Type III cement and calcium chloride or an approved accelerator. The aggregates or

water or both shall be heated during the season when the ambient temperature may drop below 60 F (15 C). Aggregates shall not be heated higher than 150 F (65 C). The temperature of the water and aggregates combined shall not be higher than 110 F (45 C) when the cement is added. The temperature of the concrete at the time of placement shall not be lower than 80 F (25 C). Insulating curing mats, approved by the engineer, shall be used throughout the curing period. A minimum of 4 hours curing time and no minimum compressive strength will be required. At the option of the contractor, in lieu of Type III cement, an approved mix containing a minimum of 8 1/2 sacks per cubic yard (475 kg/m<sup>3</sup>) of Type I cement may be used with an accelerator and/or other admixtures approved by the engineer. If this option is selected, the contractor shall provide a trial mix to determine the approximate cure time needed to achieve a compressive strength of 3500 pounds per square inch (24 MPa). Compressive specimens shall be prepared in accordance with current MoDOT methods and cured to simulate actual field conditions. Testing of compressive specimens shall be performed by methods and at facilities acceptable to the engineer. The repaired pavement shall not be opened to traffic until the cure time has elapsed. A new trial mix may be required if the engineer determines the field conditions vary substantially from trial mix conditions.

**613.2.7.2** If the pavement has been resurfaced, the repaired area shall be filled to the surface of the existing asphalt with portland cement concrete.

**613.2.8** Where subsequent resurfacing operations are not specified, both transverse ends of all new portland cement concrete repairs shall be sawed 2 inches (50 mm) deep and 3/8 inch (9.5 mm) wide, and sealed in accordance with [Sec 1057](#).

**613.2.9** Weather limitations shall be in accordance with [Sec 502.4](#).

### **613.3 Methods of Measurement.**

**613.3.1** Measurement for full or partial depth sawing will be made to the nearest linear foot (0.5 m) of perimeter diamond saw cut.

**613.3.2** Measurement for drilling dowel holes and furnishing and installing dowels will be made per dowel.

**613.3.3** Measurement for furnishing and placing portland cement concrete and wire fabric, if applicable, or bituminous mixture, if applicable, will be made to the nearest 1/10 square yard (0.1 m<sup>2</sup>).

**613.3.4** Measurement for partial depth repairs for removing, furnishing and placing material as specified will be made to the nearest 1/10 square yard (0.1 m<sup>2</sup>).

**613.4 Basis of Payment.** The accepted quantities of full depth pavement repair will be paid for at the unit price for each of the pay items included in the contract. The accepted quantities of partial depth pavement repair will be paid for to the nearest 1/10 square yard (0.1 m<sup>2</sup>) of area repaired. In addition, subgrade compaction and aggregate base will be paid for as follows.

**613.4.1** Subgrade compaction will be paid for in accordance with [Sec 210](#) except measurement will be made to the nearest square yard (square meter).

**613.4.2** Aggregate base will be paid for in accordance with [Sec 304](#). However, no direct payment will be made for aggregate base material used to replace unstable subgrade.

## SECTION 614

### DRAINAGE FITTINGS

#### SECTION 614.10 GRATES AND BEARING PLATES

**614.11 Description.** This work shall consist of furnishing and installing grates and bearing plates of the size and design shown on the plans.

**614.12 Material.** Grates and bearing plates shall be constructed of structural steel meeting the requirements of AASHTO M 183.

**614.13 Construction Requirements.** Grates and bearing plates shall be fabricated as shown on the plans. Welds shall be of full section and sound throughout. Obvious dimensional defects and structural discontinuity of welds will be cause for rejection. All welding residue shall be removed by chipping, brushing or other suitable means. If grates are to be galvanized, all tightly contacting surfaces shall be completely sealed by welding. Removal of welding beads will not be required except on bearing surfaces. Grates and bearing plates shall be hot-dip galvanized after fabrication.

**614.13.1** Grates and bearing plates shall be galvanized in accordance with the requirements of AASHTO M 111. Bolts, nuts and washers shall be galvanized in accordance with the requirements of AASHTO M 232, or they may be mechanically galvanized. If mechanically galvanized, the coating thickness, adherence and quality requirements shall conform to AASHTO M 232, Class C. Damaged spelter coating shall be repaired in accordance with [Sec 712.14](#).

**614.14 Method of Measurement.** Measurement will be made to the nearest 10 pounds (5 kg) for each unit.

**614.15 Basis of Payment.** The accepted quantity of grates and bearing plates will be paid for at the contract unit price.

#### SECTION 614.20 AUTOMATIC FLOODGATE

**614.21 Description.** This work shall consist of furnishing and installing automatic floodgates of standard design to fit the opening shown on the plans. Type 1 floodgates shall be installed on concrete structures. Type 2 floodgates shall be installed on corrugated metal pipe. Gates shall be of the off-vertical type if shown on the plans.

**614.22 Material.**

**614.22.1** Automatic floodgates shall have a frame and flap constructed of cast iron meeting the requirements of AASHTO M 105, minimum Class 30.

**614.22.2** Each link shall be provided with commercial grade bronze bushings permanently lubricated and installed at the factory. For hydraulic heads greater than 10 feet (3 m), the bottom of the links shall be provided with an adjusting screw to align seating faces on the cover properly with respect to the seat. For hydraulic heads less than 10 feet (3 m), adjusting screws are not required, however, the seating faces on the cover shall properly align with respect to the seat. The links shall be designed to prevent the cover from rotating far enough to become wedged in the open position.

**614.22.3** The seat shall be one-piece cast iron with a raised section around the perimeter of the waterway opening to provide the seating face, and shaped to provide two pivot bosses extended above the top of the waterway opening.

**614.22.4** All anchor bolts, assembly bolts, screws and nuts shall be of stainless steel having ample section to withstand safely the forces created by operation of the gate under a hydraulic head. Quantity and size of anchor bolts shall be as recommended by the manufacturer, except there shall be a minimum of four bolts. Each anchor bolt shall be furnished with two nuts to facilitate installation and alignment of the flat back gates when attached to concrete.

**614.22.5** The contractor shall furnish in triplicate a manufacturer's certification that the floodgate being supplied conforms to the specified material requirements and that the floodgate will operate properly under the specified hydraulic head. If the hydraulic head is not specified, the height of fill above the pipe will be considered the hydraulic head.

**614.23 Construction Requirements.** Automatic floodgates shall be carefully machined, watertight and automatic in operation. They shall react to any difference in water level and shall be hinged to seat accurately. They shall be attached in accordance with the manufacturer's recommendations for corrugated metal pipes or concrete structures.

**614.24 Basis of Payment.** The accepted quantity of automatic floodgates, complete in place, will be paid for at the unit price for each of the pay items included in the contract.

#### **SECTION 614.30 MANHOLE FRAME AND COVER AND CURB INLET**

**614.31 Description.** This work shall consist of furnishing and installing manhole frames and covers, curb inlets or any items of similar nature. They shall be of the size and type necessary to fit appurtenant details shown on the plans, shall be of a standard design and shall meet the approval of the engineer.

**614.32 Material.** These items shall be constructed of cast iron meeting the requirements of AASHTO M 105. Specific classes, if required, will be shown on the plans.

**614.33 Construction Requirements.** Bearing surfaces of both the frame and cover shall be finished to a non-rocking fit. The fixture shall be set securely as shown on the plans to prevent displacement during the placing of the concrete. All concrete placed adjacent to the fixture shall be thoroughly vibrated.

**614.34 Basis of Payment.** The accepted quantity of these items or items of similar nature, complete in place, will be paid for at the unit price for each of the pay items included in the contract.

## SECTION 615

### OFFICE FOR ENGINEER

**615.1 Description.** This work shall consist of the furnishing and maintaining of an office for the engineer in accordance with the contract.

#### **615.2 Construction Requirements.**

**615.2.1** The contractor shall provide the office as the first order of work. The office shall be located on the project right of way unless another suitable location is approved by the engineer.

**615.2.2** Unless otherwise approved by the engineer, the office shall consist of two trailers, each with minimum outside dimensions of 10 x 40 feet (3 x 12 m), excluding hitch. One of the trailers shall have sanitary facilities, telephone, a separate enclosure for the Resident Engineer and other facilities required in the contract. This trailer shall be so constructed as to provide finished paneled walls, vinyl floor covering, adequate lighting fixtures and a minimum of partitions or attachments which will reduce the effective working area. The second trailer shall have storage room and a minimum of attachments.

**615.2.3** The trailers shall be weatherproof, insulated and with central air-conditioning and gas heating facilities capable of maintaining a temperature of 72 F (22 C).

**615.2.4** Adequate light, both artificial and natural, along with sufficient windows to provide acceptable ventilation, shall be provided. All doors and windows shall be equipped with vandal proof grills and locking facilities. Electric, water and sanitary hookups shall be provided.

**615.2.5** Metal furniture in acceptable condition shall be provided by the contractor in the following quantities:

3 - Desks	1 - Steno Chair
1 - Steno Desk	6 - Chairs (2 with arms)
2 - Drafting Tables	10 - Chairs (folding type)
4 - Tables	2 - Drafting Stools
3 - Swivel Chairs	1 - Electric Water Cooler
1 - Plan File Cabinet (10 drawer)	1 - Bulletin Board
2 - Filing Cabinets (3 drawer)	

**615.2.6** The contractor shall furnish four 10-pound (4.5 kg) dry chemical type fire extinguishers including refills and inspection as necessary, aggregate surfaced parking area of sufficient capacity for eight vehicles, and a sand curing pit. If specified in the contract, the contractor shall furnish and install a 6-foot (1830 mm) chain-link fence.

**615.2.7** The trailers, equipment and furnishings shall remain the property of the contractor, and after being vacated by the Resident Engineer all portions of the installation on the right of way shall be promptly removed. The right of way shall be restored to a satisfactory condition.

**615.3 Basis of Payment.** The accepted office for engineer complete with furnishings, maintenance, all utilities and heating facilities including operation and fuel, fence if required, ground rentals, labor, tools, supplies and removal will be paid for at the contract unit price.

## SECTION 616

### TRAFFIC CONTROL PLAN

**616.1 Description.** This work shall consist of furnishing and installing traffic control devices in accordance with the contract and as directed by the engineer.

**616.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Construction Sign and Reflective Material	1041
Flexible Non-Metallic Drum-Like Channelizers	1063

**616.2.1 Flashing Electric Light.** This unit shall be an 8-inch (200 mm) conventional traffic signal section meeting the requirements of [Sec 902](#). Each unit shall contain a yellow lens. The contractor shall furnish lamps for the flashing electric lights. Each unit shall contain a minimum 8-inch (200 mm) tunnel visor and be equipped for single section mounting. The flasher unit may be of the synchronous motor or NEMA solid state type operated on 120 VAC. Flashing electric lights which will become property of the Commission shall be controlled by NEMA solid state flasher units and be connected to a permanent power supply. Two-circuit flasher units shall be used to provide alternate flashing of the lights when mounted on barricades or bridges. Indications shall be flashed at not less than 50 nor more than 60 flashes per minute, with an approximate 50 percent on-off ratio. The contractor shall, at no cost to the Commission, provide all necessary connections to an electrical power source for operation of flashing electric lights.

#### 616.3 Construction Requirements.

**616.3.1** The contractor shall furnish, install, maintain, clean and relocate all signs, drums, cones, barricades, delineators, object markers, flashing arrow panels, channelizing devices, lights and other traffic control devices shown on the plans, or as directed by the engineer. All traffic control devices shall meet the requirements of the latest editions of the MUTCD and the *Missouri Quality Standards for Work Zone Traffic Control Devices*. Any unacceptable device shall be replaced by the contractor as soon as possible but not to exceed 24 hours after the contractor had been notified.

**616.3.1.1** All signs, except the project terminal signs, shall be covered, set aside, turned, removed or relocated as work progresses or is completed and their necessity ceases to exist. Sign covering shall meet the requirements of the latest edition of the *Missouri Quality Standards for Work Zone Traffic Control Devices*. All traffic control devices shall be removed after completion of construction and shall remain the property of the contractor unless specified otherwise.

**616.3.2** The contract will indicate the minimum requirements for traffic control. The contractor may, at no cost to the Commission, add to the traffic control plan any standard signs or traffic control devices the contractor considers necessary to adequately protect the public and the work.

**616.3.2.1** Signs and sign quantities for blasting areas are not included in the contract traffic control plan. It shall be the contractor's responsibility and expense to furnish, install, maintain



and remove blasting zone signing in accordance with the MUTCD. Placement of blasting area signing shall be subject to the engineer's approval.

**616.3.2.2** Some projects require establishment of stage construction and the traffic control plans are developed accordingly. Work in any of the specified construction stages or other unrelated items of work may be accomplished concurrently with another specified stage provided that no interference with the prescribed handling traffic procedures will occur. The contractor shall submit traffic control plan revisions to the engineer should the contractor choose to deviate from the stages shown in the contract. All changes to the traffic control plan are subject to the engineer's approval and shall be verified in writing prior to implementation. Sign and device quantities shall be adjusted accordingly.

**616.3.2.3** If the engineer determines the need for additional signs or other traffic control devices not included in the traffic control plan, the contractor will be notified in writing to provide the additional signs or devices. Reimbursement for authorized changes to the traffic control plan will be made in accordance with [Sec 104.3](#), unless covered by contract unit prices.

**616.3.2.4** When the traffic control plan is initially implemented, and each time a significant change occurs in the plan or a new stage of the traffic control plan is implemented, the contractor and the engineer shall review the traffic flow through the project. Together, they shall drive through the traffic control zone(s) of the project in both directions, at least once each direction during both daylight and nighttime conditions within the next twenty-four hour period, to determine that traffic can safely and efficiently pass through the area covered by the traffic control plan, that all signs and traffic control devices are in place, visible and functioning properly, and that there are no hazards to traffic in or adjacent to the roadway which should be moved, eliminated or corrected. If it is determined that a deficiency exists, the contractor shall take corrective action as directed by the engineer. No additional payment shall be made for the contractor's compliance with this specification if the corrective action is within the requirements of the traffic control plan. The contractor will be compensated for any corrective action which is in addition to the requirements of the traffic control plan. A nighttime review of the traffic control devices is not required when only beginning and ending construction signs are in place.

**616.3.2.5** The contractor shall make a visual inspection of the traffic control devices on sections of the project which are open to traffic and on sections which are adjacent to those sections open to traffic. This shall occur after the traffic control devices are in place to the satisfaction of the engineer and the contractor as required by [Sec 616.3.2.4](#). This inspection shall ascertain that all traffic control devices and signs are in place and functioning properly, and that there are no deficiencies or corrections needed in the work zone. A brief written summary of this inspection shall be made and shall include but not necessarily be limited to the time of the inspection, the person performing the inspection, the general weather, roadway conditions and visibility and any deficiencies detected and changes or corrections made. If it is determined in this inspection that a deficiency exists in the traffic control plan, the contractor shall report it verbally to the engineer. The contractor shall submit a written summary of inspections performed to the engineer on a weekly basis.

**616.3.2.6** All traffic control devices shall be inspected at least daily with the following exceptions:

(a) Non-portable construction signs and pavement markings on sections of the project with no project imposed speed limit restrictions shall be inspected at least weekly.

(b) Portable construction signs, including cones, flashing arrows and channelizers used with the signs, shall be inspected a minimum of two times each day. The interval between inspections shall not exceed six hours during active work.

(c) Traffic control devices in the work zone shall be reinspected after finding any physical evidence or other information suggesting an accident has occurred in the work zone.

**616.3.2.7** The contractor shall give written notice to the engineer of any pedestrian or vehicular accident where physical evidence or other information suggests an accident has occurred in the work zone. The contractor shall obtain and provide to the engineer copies of law enforcement accident reports for any accidents in the work zone which may come to the contractor's attention.

**616.3.3** All flagging operations, flagger attire, hand signals and traffic control devices shall be in accordance with the MUTCD. Flaggers shall be provided as specified in the plans or when equipment is crossing a road open to vehicular traffic. When two-way traffic is maintained over a single lane, each flagger involved in the traffic flagging operation shall be equipped with a portable, two-way, communications method approved by the engineer.

**616.3.4** The length of time that the contractor may maintain the lane closures or one-way traffic operations shall be kept to a minimum and shall be subject to the engineer's approval. The contractor shall furnish the engineer a traffic control plan indicating the proposed method to achieve temporary stoppage of all traffic lanes if construction operations require such. The plan shall indicate any advance warning or regulatory signs, if used, and their locations; flagmen, if used, and their locations; and all other traffic control devices and their locations which may be used to stop all traffic. A one time payment for traffic control devices used to temporarily stop all traffic will be made at the unit price for those like items contained in the contract. No direct payment will be made for removing or reusing these particular signs as an indeterminate number of occasions for their use may occur. Traffic control devices used by the contractor which do not have a specific pay item in the contract shall be supplied, installed, maintained and removed by the contractor at no cost to the Commission.

**616.3.5** The requirements of this specification shall not relieve the contractor of the responsibility for protecting both the public and the work. Should the contractor fail to clean, repair, replace or otherwise maintain the traffic control devices when directed to do so by the engineer, one or more of the following actions will be taken:

(a) The engineer may employ another agency to correct deficiencies in signing or warning devices and deduct the cost from the contractor's pay estimate.

(b) Suspend all pay estimates until deficiencies are corrected.

(c) Place the contractor in default if the situation continues after two written orders fail to produce favorable results.

**616.3.6** The contractor shall ensure that work area lighting does not cause a blinding effect to drivers.

**616.4 Basis of Payment.** Signs and other traffic control devices specified in the traffic control plan or authorized by the engineer will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for any incidental items necessary to complete the work unless specifically provided as a pay item in the contract. No direct payment will be made for cleaning, repair or replacement of traffic control devices.

## SECTION 617

### CONCRETE TRAFFIC BARRIER

**617.1 Description.** This work shall consist of constructing a concrete traffic barrier in conformity with the lines, dimensions and typical sections shown on the plans. The concrete traffic barrier may be either cast-in-place or extruded at the option of the contractor. Temporary traffic barrier may be precast.

**617.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete	<a href="#">1036</a>
Concrete Curing Material	<a href="#">1055</a>
	<b>Specification</b>
Prestressing Strands	AASHTO M 203

Concrete traffic barriers shall be constructed of Class B or B-1 concrete. Material, proportioning, air-entraining, mixing, slump and transporting shall be in accordance with [Sec 501](#). Concrete shall be placed and finished in accordance with the applicable provisions of [Sec 703](#).

#### **617.3 Construction Requirements.**

**617.3.1** Concrete traffic barriers shall conform to the dimensions shown on the plans. Forms shall be of either metal or wood, of sufficient strength to resist springing.

**617.3.2** Permanent concrete traffic barriers shall be constructed by using an extrusion machine or other equipment specifically designed for constructing cast-in-place reinforced concrete barriers, provided that the finished barrier is true to line and grade and the exposed surfaces conform to the requirements of [Sec 617.3.5](#).

**617.3.3** Precast units shall not be removed from forms and casting beds until a compressive strength of not less than 1400 pounds per square inch (9.5 MPa) is attained. Compressive strength will be determined by tests made in accordance with MoDOT methods.

**617.3.4** Permanent traffic barrier shall be cured in accordance with [Sec 502.12](#).

**617.3.5** For permanent traffic barrier, surface shall be of smooth and even texture, true to line and grade. Surfaces which do not exhibit a smooth, even texture shall be sanded with power sanders or other approved abrasive means until the required texture is attained.

**617.3.6** When cast-in-place or extruded construction is used, contraction joints shall be constructed as shown on the plans. Insertion of joint filler will not be required.

**617.3.7** When concrete traffic barriers are required to be marked with a 13 inch (325 mm) stripe, the material shall comply with [Sec 620.50](#).

**617.4 Method of Measurement.**

**617.4.1** For the purpose of measurement and payment, Type A Concrete Traffic Barrier will be considered that which is cast or formed with two traffic faces regardless of the width of the barrier. Type B Concrete Traffic Barrier will be considered that which is cast or formed with one traffic face.

**617.4.2** Measurement of concrete traffic barrier will be made to the nearest 1/2 linear foot (0.1 m) for each continuous length and totaled to the nearest linear foot (0.5 m) for the sum of the lengths. The length will be measured separately for each type. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**617.5 Basis of Payment.** The accepted quantities of concrete traffic barrier, complete in place, will be paid for at the unit price for each of the pay items included in the contract.

## **SECTION 618**

### **MOBILIZATION**

**618.1 Description.** This item shall consist of preparatory work and operations, including, but not limited to, those necessary for the movement of personnel, equipment, supplies and incidentals to the project site; for the establishment of all offices, buildings and other facilities necessary for work on the project except as provided in the contract as separate pay items; and for all other work and operations which must be performed or costs incurred prior to beginning work on the various items on the project site.

#### **618.2 Basis of Payment.**

**618.2.1** Payment for the actual cost of the contract bond and railroad liability insurance will be authorized upon presentation of invoices at least four days prior to the estimate date. Receipted invoices for payments previously allowed on the estimate shall be submitted to the engineer within 27 days of the date of the estimate on which payment was made, or such payment will be deducted from future estimates. The amount paid, but not more than the price bid for mobilization, will be deducted from the contract lump sum price for mobilization and the remainder will be used as the basis for partial payments which will be allowed on the next estimate as follows:

- (a) When five percent or more of the original contract amount is earned, 25 percent.
- (b) When ten percent or more of the original contract amount is earned, an additional 25 percent.
- (c) When 25 percent or more of the original contract amount is earned, an additional 25 percent.
- (d) When 50 percent or more of the original contract amount is earned, the final 25 percent.

**618.2.2** Nothing herein shall be construed to limit or preclude partial payments otherwise provided by the contract.

## SECTION 619

### PAVEMENT EDGE TREATMENT

**619.1 Description.** This work shall consist of the elimination of pavement edge differential.

**619.2 Material.**

**619.2.1** Temporary concrete traffic barrier shall comply with [Sec 617](#).

**619.2.2** Wedge slope shall be constructed of an approved fill material, a commercially available aggregate base material, a commercially available bituminous mix or an approved preformed unit. Acceptance of wedge slope material will be based on visual examination.

**619.3 Construction Requirements.** At the contractor's option, elimination of pavement edge differential may be accomplished by either conducting operations in such a manner that traffic is exposed to no more than a two-inch (50 mm) differential, by constructing a wedge shaped slope adjacent to the pavement edge or by furnishing and installing temporary concrete traffic barrier.

**619.3.1** Wedge slope shall be as shown on the plans or as directed by the engineer. Slope material, other than preformed units, shall be compacted by a roller, mechanical tamper or other methods approved by the engineer, until there is no visible evidence of further consolidation.

**619.3.2** Wedge slope material shall be removed and the pavement edge returned to a vertical face prior to placement of adjacent shoulder or pavement material. Material used to construct wedge slope shall be disposed of as approved by the engineer.

**619.3.3** Temporary concrete traffic barrier shall be constructed as shown on the plans or as directed by the engineer.

**619.4 Method of Measurement.**

**619.4.1** Measurement will be made to the nearest linear foot (0.5 m) along each edge of pavement for all locations actually treated. No location will be measured more than once, regardless of the number of applications.

**619.4.2** Final measurement will not be made except for authorized changes during construction or when appreciable errors are found in the contract quantities.

**619.5 Basis of Payment** The accepted quantity of edge treatment will be paid for at the contract unit bid price for the units constructed or the units shown in the contract, whichever is greater. Payment shall include all material and labor necessary to eliminate the need for or to construct, maintain, replace, relocate, remove and dispose of edge treatment. No direct payment will be made for more than one application at any location.

## SECTION 620

### PAVEMENT MARKING

**620.1 Description.** This work shall consist of furnishing and installing pavement marking, either permanent or temporary in nature.

#### **620.2 Construction Requirements.**

**620.2.1** All pavement markings shall conform to the latest edition of the Manual on Uniform Traffic Control Devices and any revisions thereof.

**620.2.2** All pavement marking shall be installed at the locations and shall be of the colors, widths and types shown on the plans unless otherwise directed by the engineer.

**620.2.3** When installing permanent marking, the contractor shall begin intermittent centerline and lane line striping at the beginning of the last existing 10-foot (3 m) stripe in order to maintain a 40-foot (12 m) cycle along the pavement.

**620.2.4** Stop lines, arrows, words and symbols shall appear without lines or breaks.

**620.2.5** On roadways open to traffic, any intermediate or previously existing pavement marking obliterated by coldmilling or resurfacing operations, except edge lines, shall be replaced with the type of marking material as shown on the plans no later than the end of the same day. If edge lines are specified, they shall be replaced no more than fifteen calendar days from the time they were obliterated. Pavement marking shall be replaced in the same configuration as the previously existing marking unless otherwise shown on the plans or directed by the engineer.

**620.2.5.1** At the option of the contractor, at the contractor's expense, temporary pavement marking of centerlines and lane lines may be provided as described below for a period of no more than five calendar days before final marking is completed. During the contractor's operation, not more than one mile (1.6 km) of roadway behind the operation shall be unmarked. At the end of each day's run, the temporary marking shall be placed so that when combined with existing or previously placed markings the entire project is marked.

**620.2.5.1.1** On three or more lane roadways without no passing zone marking, all marking shall conform to [Sec 620.40](#) and shall be installed as shown on the plans. Intermittent marking shall be a minimum of 4 feet (1200 mm) long on a 40-foot (12 m) cycle.

**620.2.5.1.2** On two or three lane roadways with two-way traffic and no passing zone marking, all yellow centerline marking shall be replaced with temporary raised pavement markers with yellow on both sides. White lane line marking on climbing lanes shall be replaced with raised pavement markers with white on one side. Temporary raised pavement markers shall be placed at approximately 40-foot (12 m) intervals and shall conform to [Sec 620.70](#). Sign WO8-12, "No Center Stripe", shall be installed throughout the section where the striping has been obliterated at 1/2-mile (1 km) intervals and 150 feet (45 m) from side roads or as shown on the plans. These signs shall be displayed only where the striping has been obliterated and shall be removed or covered where final striping is complete.

**620.2.5.1.3** On resurfacing projects, when the adjacent layer of resurfacing has not been placed and the existing centerline or lane line marking has been obliterated, the temporary

marking shall be placed on the higher layer at the centerline of the roadway or lane. Any temporary pavement marking damaged, displaced or missing before the final pavement marking is placed shall be replaced by the contractor at no cost to the Commission.

**620.3 Method of Measurement.** Measurement of pavement marking will be made as described in the following sections.

**620.3.1** Measurement of "No Center Stripe" signs will be made to the nearest square foot (0.1 m<sup>2</sup>).

**620.4 Basis of Payment.** Accepted pavement marking will be paid for at the unit price bid for applicable pay items included in the contract as described in the following sections.

**620.4.1** Payment for installing, maintaining, covering and removing "No Center Stripe" signs will be made at the contract unit price.

## **SECTION 620.10 PREFORMED PAVEMENT MARKING TAPE**

**620.11 Description.** This work shall consist of furnishing and placing preformed marking tape at the locations as shown on the plans or as directed by the engineer.

The contractor has the option to use thermoplastic pavement material in lieu of Type 1 preformed marking tape at the price bid.

**620.12 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Type I Preformed Marking Tape	<a href="#">1048.2</a>

### **620.13 Construction Requirements.**

**620.13.1** Type 1 preformed marking tape shall be installed as shown on the plans, or as directed by the engineer. The pavement width of asphaltic concrete shall be adjusted such that the tape will not fall on a longitudinal joint.

**620.13.1.1** Arrows, words and symbols shall be white and may be formed from one piece, multiple pieces, or strips of Type 1 tape material.

**620.13.1.2** Type 1 tape shall be embedded or inlaid in the asphalt surface by the final roller or other roller as approved by the tape manufacturer. All rolling shall be completed prior to the surface temperature decreasing to 120 F (50 C).

### **620.13.2 Method of Measurement.**

**620.13.2.1** Measurement of 4-inch (100 mm) preformed marking tape lines will be made to the nearest 10 linear feet (5 m) of marking tape used.

**620.13.2.2** Measurement of preformed marking tape arrows, words and symbols will be made per each.

**620.13.2.3** Measurement of 6-inch (150 mm), 8-inch (200 mm) and 24-inch (600 mm) preformed marking tape lines will be made to the nearest linear foot (0.5 m) of marking tape at the specified width.



**620.13.3 Basis of Payment.** Accepted preformed pavement marking tape will be paid for at the unit price for each of the pay items included in the contract.

## **SECTION 620.20 THERMOPLASTIC PAVEMENT MARKING**

**620.21 Description.** This work shall consist of furnishing material and placing thermoplastic pavement marking at locations and of the dimensions shown on the plans or as directed by the engineer.

**620.22 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

<b>Item</b>	<b>Section</b>
Thermoplastic Pavement Marking Material	<a href="#">1048.3</a>

### **620.23 Construction Requirements.**

**620.23.1 Equipment.** All equipment for application of thermoplastic marking material shall be of such design and maintained in such condition as to properly heat, mix and apply the material.

**620.23.1.1 Melting Kettle.** The melting kettle shall be capable of heating the thermoplastic material to its recommended application temperature without scorching and shall be capable of maintaining that temperature. The heating kettle shall have a heat transfer medium and the flame shall not come in direct contact with the material container surface. A temperature gauge shall be visible on the outside of the kettle to indicate the temperature of the thermoplastic material. The melting kettle shall have a continuous mixer or agitator capable of thoroughly mixing the material at such a rate as to maintain homogeneity of material and uniformity of temperature throughout.

**620.23.1.2 Thermoplastic Dispensing Devices.** The equipment may be mobile or portable and shall be capable of applying molten thermoplastic material at the temperature recommended by the manufacturer of the thermoplastic material in lines from 4 to 12 inches (100 to 300 mm) wide at a 125 mils (3 mm) thickness. Dispensing devices shall be of the extrusion type.

**620.23.1.2.1** Extrusion dispensing devices shall be capable of depositing a mass of molten thermoplastic material on the pavement where it is immediately shaped to the specified width and thickness. The extrusion device shall have a visible temperature gauge to allow monitoring of the temperature of the thermoplastic material near the point of deposition.

**620.23.1.3 Glass Bead Dispenser.** All thermoplastic dispensers shall be equipped with a drop-on type glass bead dispenser. The glass bead dispenser shall be located so as to drop the glass beads immediately after the molten thermoplastic material is applied. The glass bead dispenser shall be adjustable to regulate flow of the beads and shall uniformly dispense the glass beads.

**620.23.2 Surface Preparation.** The pavement surface on which the thermoplastic material is to be placed shall be clean and dry. Even if the pavement is visibly dry, subsurface moisture may be present in amounts sufficient to affect bonding. If bonding is decreased due to excess moisture, marking operations shall cease until the pavement dries. Applied markings shall have no more than five percent by area of holes, voids or blisters.

**620.23.2.1** Pavement surfaces shall be inspected for cleanliness and any dirt, debris or other contaminants on the surface to be marked shall be removed. Existing pavement markings, including any type of temporary pavement marking, that would prevent a mechanical bond between the thermoplastic and the pavement shall be removed by methods approved by the engineer. Any curing compound on the new concrete pavements shall be removed by means acceptable to the engineer.

**620.23.3 Temperature Limitations.** The pavement surface where the thermoplastic material is to be placed shall have a minimum temperature of 60 F (15 C). The air temperature shall be at least 50 F (10 C) during marking operations. The pavement surface temperature and air temperature shall be determined before the start of each day of marking operation and at any other time deemed necessary by the engineer. Temperatures are to be obtained in accordance with MoDOT Test Method T20.

**620.23.4 Primer Application.** A primer shall be applied to bituminous surfaces over two months old and all concrete surfaces. Primer is not required on new bituminous surfaces unless recommended by the manufacturer of the thermoplastic material. A new bituminous surface is one less than two months old. Primer shall be applied and cured in accordance with the recommendations of the manufacturer of the thermoplastic material.

**620.23.5 Thermoplastic Application.** The thermoplastic marking material shall be extruded onto the pavement surface.

**620.23.5.1** Thermoplastic marking material for use on new bituminous surfaces shall be alkyd thermoplastic. Material for use on surfaces other than new bituminous surfaces may be alkyd, hydrocarbon or epoxy type thermoplastic.

**620.23.5.2** The temperature of the thermoplastic at the time of application shall be 400 - 425 F (204 - 218 C) for alkyd or hydrocarbon material, and 450 - 500 F (232 - 260 C) for epoxy material. The temperature of the thermoplastic material shall be checked at the point of deposition with a calibrated thermometer at the beginning of each day's marking, after material is added to the dispensing device, after delays in the marking operation and any time deemed necessary by the engineer.

**620.23.5.3** Alkyd thermoplastic material shall not be heated above 435 F (224 C). Hydrocarbon thermoplastic material shall not be heated above 450 F (232 C). Only the quantity of thermoplastic that can be used within four hours should be heated. In no case shall any thermoplastic material be heated for more than four hours at the maximum application temperature, including initial heating. No material shall be reheated more than two times. Material subjected to these conditions will be rejected.

**620.23.5.4** Pavement striping shall comply with the standard striping practices as shown on the plans. The contractor shall begin centerline and lane line striping at the beginning of the last existing 10-foot (3 m) stripe in order to maintain a 40-foot (12 m) cycle along the entire pavement.

**620.23.5.5** Alkyd type thermoplastic lane line marking or centerline marking of the surface of newly resurfaced bituminous surfaces shall be in place at the end of each day's resurfacing if pavement is open to traffic. If the roadway shoulders are to be resurfaced, application of edge lines may be delayed for a maximum of three days or until the shoulders are resurfaced, whichever comes first.

**620.23.5.6** Finished markings shall have well defined edges and lateral deviation shall not exceed one inch in 100 feet (25 mm in 30 m). The minimum thickness of thermoplastic

markings shall be 125 mils (3 mm) and the maximum shall be 188 mils (5 mm). The thickness will be measured as a wet film except the engineer may measure cured film by placing a tape or other bond breaker prior to placing the thermoplastic material and then removing a section of cured line and measuring thickness.

**620.23.5.7** Damage to pavement marking caused by the contractor's operation, including resurfacing of shoulders, shall be repaired or replaced at no cost to the Commission.

**620.23.6 Glass Bead Application.** The drop-on glass beads shall be mechanically deposited on the molten thermoplastic line immediately after placement of the thermoplastic at the rate of at least 8 pounds per 100 square feet ( $0.4 \text{ kg/m}^2$ ) of line. The glass beads shall not be dropped at the point of deposition of the thermoplastic or ahead of that point. The beads shall adhere to the cured thermoplastic or all marking operations shall cease until corrections are made.

**620.23.7 Quality of Work.** The applied thermoplastic markings should be inspected continually for overall quality. Markings shall have clean cut edges and the finished yellow color shall be defined by Federal Test Standard 595 - Color Chip Number 13538 using Federal Test Standard 141 (Method 4252). The glass beads shall appear uniform on the entire marking surface. Adhesion to the pavement surface shall be checked with a stiff putty knife or similar instrument. The marking should not be removable from a concrete surface. The marking can be removed from a bituminous surface, however, residue of the bituminous substrate shall be stuck to the marking material.

**620.23.7.1** If the thermoplastic line does not provide initial nighttime reflectivity or, if the marking does not have the required minimum thickness or required color, the contractor shall, at no cost to the Commission, grind away the surface of the deficient portion of the marking to reduce the average thickness to 50 mils (1.25 mm) or less. The contractor shall then, at no cost to the Commission, apply additional thermoplastic material to the total thickness specified and provide a uniformly reflective surface. If the markings do not comply with the specifications for any other reason, the engineer may require complete removal or correction at the contractor's expense.

**620.23.8 Method of Measurement.**

**620.23.8.1** Measurement of 4-inch (100 mm) thermoplastic pavement marking lines will be made to the nearest 10 linear feet (5 m) from point of beginning to point of ending for each line. Where intermittent lines are specified, deduction will be made for the gaps in the striping.

**620.23.8.2** Measurement of thermoplastic pavement marking arrows, words, symbols or markings other than lines will be made per each.

**620.23.8.3** Measurement of 6-inch (150 mm), 8-inch (200 mm) and 24-inch (600 mm) thermoplastic pavement marking lines will be made to the nearest linear foot (0.5 m) of marking at the specified width.

**620.23.8.4** Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity.

**620.23.9 Basis of Payment.** The accepted quantity of thermoplastic pavement marking will be paid for at the contract unit price.

## SECTION 620.30 REMOVABLE PAVEMENT MARKING TAPE

**620.31 Description.** This work shall consist of pavement striping by application of preformed removable marking tape to delineate traffic lanes on pavements used for handling traffic during construction.

**620.32 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Preformed Removable Pavement Marking Tape	<a href="#">1048.4</a>

### 620.33 Construction Requirements.

**620.33.1** Removable pavement marking for edge lines, centerlines, stop lines and lane lines shall be as shown on the plans or as directed by the engineer.

**620.33.2** All removable pavement marking within the project limits shall be maintained by the contractor at no cost to the Commission in a manner approved by the engineer.

### 620.34 Method of Measurement.

**620.34.1** Measurement of 4-inch (100 mm) removable pavement marking lines will be made to the nearest 10 feet (5 m) as measured along the centerline of the pavement from point of beginning to point of ending for each line and totaled to the nearest 100 feet (25 m). Where intermittent lines are specified or existing, deduction will be made for gaps in the striping.

**620.34.2** Measurement of 6-inch (150 mm), 8-inch (200 mm) and 24-inch (600 mm) removable pavement marking lines will be made to the nearest linear foot (0.5 m) of marking at the specified width.

**620.34.3** Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**620.35 Basis of Payment.** The accepted quantity of removable pavement marking will be paid for at the unit price for each of the pay items specified in the contract.

## SECTION 620.40 SHORT TERM PAVEMENT MARKING TAPE

**620.41 Description.** This work shall consist of furnishing, installing and maintaining preformed short term pavement marking tape.

**620.41.1** At the option of the contractor, pavement marking paint may be used in lieu of short term pavement marking tape.

**620.42 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Preformed Short Term Pavement Marking Tape	<a href="#">1048.5</a>

### 620.43 Construction Requirements.

**620.43.1** When the contractor's work has obliterated the existing traffic striping on resurfacing projects open to through traffic, the contractor shall provide and maintain short term pavement marking. The centerline and lane lines of all lanes subject to traffic during construction shall be marked. The short term pavement marking shall be in place at the end of each day's work between all lanes open to traffic.

**620.43.2** The centerline marking shall be yellow for a two-lane road with opposing traffic and the lane lines shall be white for a two-lane road with one way traffic. Short term pavement marking shall be applied in increments 4 feet (1.2 m) long parallel to the direction of traffic flow at approximately 40-foot (12 m) intervals.

**620.43.3** The centerline marking of pavement of sufficient width to accommodate four or more undivided lanes carrying opposing traffic shall be marked with two parallel yellow lines separated by a 4-inch (100 mm) space. Lane lines for these pavements shall be white in increments 4 feet (1.2 m) long at approximately 40-foot (12 m) intervals.

**620.44 Method of Measurement.**

**620.44.1** Measurement of short term pavement marking will be made to the nearest 1/10 mile (150 m) as measured along the centerline of the pavement, or each pavement of a divided highway, regardless of the number of applications. Where intermittent pavement marking is specified, deduction will be made for gaps in the striping.

**620.44.2** Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**620.45 Basis of Payment.** The accepted quantity of short term pavement marking will be paid for at the contract unit price.

**SECTION 620.50 PAINT FOR PAVEMENT MARKING**

**620.51 Description.** This work shall consist of furnishing and placing waterborne paint and glass beads for pavement or concrete traffic barrier marking at locations and of the dimensions shown on the plans or as directed by the engineer.

**620.52 Material.** Waterborne traffic paint shall be used as specified in the plans or as approved by the engineer. Glass beads shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Drop-On Glass Beads	<a href="#">1048.3.6</a>

**620.53 Construction Requirements.**

**620.53.1 Equipment.** All equipment for application of marking paint shall be of such design and maintained in such condition to properly and evenly apply marking paint and drop-on glass beads.

**620.53.2 Surface Preparation.** The surface on which paint is to be placed shall be clean and dry. Any dirt, debris or other contaminants on the surface to be marked shall be removed.

**620.53.3 Temperature and Moisture Limitations.** The air temperature shall be at least 50 F (10 C) during marking operations. Paint shall not be applied in damp conditions or if there is any evidence of surface moisture on the pavement.

**620.53.4 Paint Application.**

**620.53.4.1** Paint shall be machine applied using spray guns designed and adjusted to apply paint at required thickness and width. If there is any evidence of gun clogging, splattering or uneven paint distribution, painting operations shall cease until equipment is restored to proper operation.

**620.53.4.2** Painting of stop lines, arrows, words and symbols may be applied by hand using paint spray equipment. Equipment shall be capable of applying paint evenly to the required thickness. For arrows, words and symbols, templates that are pre-cut to the dimensions shown on the plans shall be used.

**620.53.4.3** Paint shall be applied to a nominal thickness of 15 mils (0.4 mm). At the request of the engineer, the wet film thickness of the applied paint shall be tested with a paint thickness gauge.

**620.53.4.4** In cooler weather, paint may be heated to a maximum temperature of 90 F (32 C) before application.

**620.53.4.5** Finished markings shall have well defined edges and lateral deviation shall not exceed one inch in 100 feet (25 mm in 30 m).

**620.53.5 Glass Bead Application.** Drop-on glass beads shall be mechanically applied to the wet paint directly behind the paint spray guns. Glass beads shall be applied evenly at a minimum rate of 8 pounds per gallon (0.95 kg/L) of paint. If the beads do not adhere to the cured paint, all marking operations shall cease until corrections are made.

**620.53.5.1** For stop lines, arrows, words and symbols, glass beads may be applied by hand. Glass beads shall be applied evenly and completely cover the painted area. If the beads do not adhere to the cured paint, all marking operations shall cease until corrections are made.

**620.53.6 Quality of Work.** The applied marking paint will be inspected continually for overall quality. The finished white color shall be free from tint, furnishing good opacity and visibility under both daylight and artificial light. The finished yellow color shall be defined by Federal Test Standard 595 - Color Chip Number 13538 using Federal Test Standard 141 (Method 4252). The glass beads shall appear uniform on the entire marking surface. The cured paint shall properly adhere to the surface.

**620.53.6.1** If the marking paint does not provide initial nighttime reflectivity or if the marking does not have the required minimum thickness or required color, the contractor shall, at no cost to the Commission, re-apply the marking paint to the required thickness and shall meet all requirements as described above.

**620.54 Method of Measurement.**

**620.54.1** Measurement of 4-inch (100 mm) pavement marking paint lines will be made to the nearest 10 linear feet (5 m) from point of beginning to point of ending for each line. Where intermittent lines are specified, deduction will be made for the gaps in the striping.

**620.54.2** Measurement of pavement marking paint arrows, words, symbols or markings other than lines will be made per each.

**620.54.3** Measurement of 6-inch (150 mm), 8-inch (200 mm) and 24-inch (600 mm) pavement marking paint lines will be made to the nearest linear foot (0.5 m) of marking at the specified width.

**620.54.4** Final measurement will not be made except for authorized changes during construction or where errors are found in the contract quantity.

**620.55 Basis of Payment.** The accepted quantity of pavement marking paint will be paid for at the contract unit price.

## **SECTION 620.60 PAVEMENT MARKING REMOVAL**

**620.61 Description.** This work shall consist of all necessary operations for removal of existing pavement markings, including the removal of painted lines, thermoplastic pavement marking, preformed pavement marking tape or a preformed removable pavement marking tape when no longer required.

**620.62 Construction.** Removal of all pavement markings within the project limits shall be as shown on the plans. Pavement markings shall be completely removed to the satisfaction of the engineer with minimal damage to the pavement. The pavement surface shall not be left scarred with an image which might mislead traffic. Any excess damage or scarring of the pavement shall be repaired at the contractor's expense.

### **620.63 Method of Measurement.**

**620.63.1** Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**620.63.2** Measurement for the removal of pavement markings will be made to the nearest 10 feet (0.5 m) as measured along the centerline of the pavement from point of beginning to point of ending for each line and totaled to the nearest 100 feet (30 m). Where intermittent lines are specified or existing, deduction will be made for gaps in the removal. Measurement will not be made for removal of pavement marking within the limits of a bypass roadway or other roadway to be obliterated at the completion of the project.

**620.64 Basis of Payment.** The accepted quantity of pavement marking removal will be paid for at the unit price for each of the pay items specified in the contract.

## **SECTION 620.70 TEMPORARY RAISED PAVEMENT MARKERS**

**620.71 Description.** This work shall consist of installing and maintaining reflectorized temporary raised pavement markers, hereafter called markers, on roadway lane lines, centerlines or edge lines.

**620.72 Material.** Markers shall consist of a plastic shell with prismatic reflective faces with a minimum of 0.38 square inches (0.002 m<sup>2</sup>) of reflective surface for each face. If reflective faces are specified on both sides, they shall be 180 degrees opposed. The marker shall be fitted with a pressure-sensitive adhesive for application to a primed surface or may be applied to the pavement surface with a bituminous adhesive material. The markers shall be subject to approval by the engineer.

**620.73 Construction Requirements.**

**620.73.1** Markers shall be installed at the locations and shall be of the colors shown on the plans unless otherwise directed by the engineer. Reflective faces shall be oriented to face traffic.

**620.73.2** On resurfacing projects, markers shall be removed on intermediate lifts of asphalt before additional lifts are laid above them. Markers on final wearing surfaces shall be removed if specified on the plans or as directed by the engineer. No direct payment will be made for the removal of temporary raised pavement markers.

**620.74 Method of Measurement.**

**620.74.1** Measurement of temporary raised pavement markers will be made per each.

**620.74.2** Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**620.75 Basis of Payment.** The accepted quantity of temporary raised pavement markers will be paid for at the contract unit price.



## SECTION 621

### FLOWABLE BACKFILL

**621.1 Description.** This work shall consist of furnishing flowable backfill as specified on the plans or otherwise allowed for compacted backfill and other cavity filling uses.

#### **621.2 Material.**

**621.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Fly Ash	1018
Cement	1019
Admixtures	1054
Water	1070

Fine aggregate shall meet the quality requirements of [Sec 1005.2](#), except for the percent passing the No. 200 (75  $\mu$ m) sieve. It shall be fine enough to stay in suspension in the mortar to the extent required for proper flow and shall conform to the following gradation:

Sieve Size	Percent Passing
3/4 inch (19.0 mm)	100
No. 200 (75 $\mu$ m)	0-10

**621.2.2 Mixture.** The contractor shall submit to the engineer a mix design including the proportions and source of material, admixtures, dry cubic yard (cubic meter) batch weights (masses) and actual 28 day compressive test results which shall exceed 50 psi (345 kPa).

**621.2.2.1 Mix Design.** Unless otherwise specified, the mix shall contain a minimum of 100 pounds (60 kg) of cement and 250 pounds (148 kg) of fly ash per cubic yard (cubic meter), with the remainder of the volume composed of sand, water and any approved admixtures.

**621.2.2.2 Consistency.** Consistency of the fresh mixture shall be that of batter, not thin and watery. It shall be tested by filling an open-ended three inch (75 mm) diameter, six inch (150 mm) high cylinder to the top with the mixture and immediately pulling the cylinder straight up. The correct consistency of the mixture will produce an approximate eight inch (200 mm) diameter circular-type spread with no segregation. Adjustments of the proportions of fine aggregate or water may be made to achieve proper solid suspension and optimum flowability with the approval of the engineer, however the theoretical yield shall be maintained at one cubic yard (1 m<sup>3</sup>) for the given batch weights (masses).

**621.2.3** Approved commercial brand mixtures intended specifically for use as flowable backfill may be used provided the specified strengths are obtained. If approved for use, the material shall be placed in accordance with the manufacturer's recommendations which shall be furnished to the engineer. All commercial mixtures shall use 100 pounds (60 kg) or more of cement per cubic yard (cubic meter) of fill in place.

**621.2.3.1** To obtain approval of a commercial brand mixture, the manufacturer shall submit a request along with appropriate documents to the Division Engineer, Materials, for testing and evaluation. Upon approval of the material, the brand name will be placed on a list of prequalified commercial brand flowable backfill material.

**621.3 Construction Requirements.** The open ends of the area to be backfilled shall be plugged and the void area filled without the use of a vibrator.

**621.3.1** Care shall be taken to prevent the movement of any structure from its designed location or intrusion of flowable backfill into undesirable locations. If such movement or intrusion occurs, affected structures may be required by the engineer to be excavated and replaced to the proper grade at the contractor's expense.

**621.3.2** If flowable backfill is placed in more than one layer, the base layer shall be thoroughly roughened and all loose and foreign material removed before placing the next layer.

**621.3.3** No flowable backfill shall be covered or accepted until a minimum compressive strength of 30 psi (205 kPa) has been attained, as demonstrated by failure to deform or crush underfoot when a pressure of approximately 30 psi (205 kPa) is applied. Note that the material may scuff in this condition. If the backfill does not harden to support the required load, it shall be removed and replaced with an acceptable material.

**621.4 Method of Measurement.** If flowable backfill is specified, measurement will be made by the computed volume to the nearest 1/10 cubic yard (0.1 m<sup>3</sup>) of the voids to be filled, as determined from the dimensional area of the open area. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity.

**621.4.1** If flowable backfill is used as an alternate to compacted backfill specified in the contract or as shown on the plans, measurement will be made as required for the item specified.

**621.5 Basis of Payment.** If flowable backfill is specified, the accepted quantity will be paid for at the contract unit price for "Flowable Backfill", cubic yards (cubic meters).

**621.5.1** No additional payment will be made if flowable backfill is used as an alternate to compacted backfill. The accepted quantity will be paid for at the contract unit price for the item specified.

## SECTION 622

### PAVEMENT SURFACE TEXTURING AND REMOVAL

**622.1 Description.** This specification covers removing the surface of, or texturing, existing pavements and bridge decks. Traffic control shall be as specified herein or as shown in the plans.

#### SECTION 622.10 COLDMILLING EXISTING PAVEMENT FOR REMOVAL OF SURFACE

**622.10.1 Description.** This work consists of improving the profile and cross slope of the existing surface on roadways or bridge decks to the depths indicated on the plans, and removal of the milled material.

##### 622.10.2 Equipment.

**622.10.2.1** The equipment for profiling and removing the pavement surface shall be a power operated, self-propelled planing machine or grinder capable of removing a thickness of bituminous or concrete surface to the specified depth and providing a uniform profile and cross slope.

**622.10.2.2** The equipment shall be self-propelled with sufficient power, traction and stability (rigid suspension, non-pneumatic tire) to maintain accurate depth of cut and slope. The equipment shall be capable of accurately and automatically establishing profile grades within  $\pm 1/8$  inch (3 mm) each edge of the machine by referencing from the existing pavement by means of a ski or matching shoe or from an independent grade control. The equipment shall be controlled by an automatic system for controlling grade elevation and cross slope at a given rate.

**622.10.2.3** The machine shall be equipped with water spray to control dust and other particulate matter created by the cutting action. It shall also have an effective means of removing cuttings from the pavement and discharging them into a hauling unit, all in one operation as the pavement is milled.

##### 622.10.3 Construction Methods.

**622.10.3.1** When coldmilling is to be followed by resurfacing, milling shall only begin when the contractor is ready to immediately follow-up with the resurfacing operation. The milled surface shall not be exposed to traffic for an extended period of time before being resurfaced. In the event the milled surface begins to ravel under traffic or other problems resulting from the milling occur, restrictions on the amount of time that a milled area may be left open will be determined by the engineer.

**622.10.3.2** The pavement surface shall be removed to the depth, width, grade and cross section as shown on the plans or as directed by the engineer.

**622.10.3.3** The pavement planing operations except in depth transition areas shall be regulated by an automatically controlled grade leveling and slope control device. The device shall provide control for producing a uniform surface to the established grade and a cross slope conforming to the requirements of the typical section. The device shall also be equipped

with the necessary controls to permit the operator to adjust or vary the slope as directed by the engineer.

**622.10.3.4** Depth transitions at the beginning and end of a project, side roads, bridge ends or where shown on the plans shall be coldmilled by using a machine and process as approved by the engineer. Any necessary pavement marking in the transition areas shall be as directed by the engineer at no direct pay.

**622.10.3.5** The roadway pavement surface shall be removed and planed around and over manholes, utility valves and drainage appurtenances within the limits of the work as directed by the engineer. Any damage to manholes, utility valves or drainage appurtenances by the removal and planing operation shall be the responsibility of the contractor to correct. After removal of existing material around manholes, utility valves and other appurtenances in the driving lanes, the contractor shall place a temporary wedge of bituminous material at a slope no steeper than one inch in 4 feet (20 mm/m) around the appurtenance. Bituminous wedges shall be removed prior to resurfacing. No direct payment will be made for compliance with this specification.

**622.10.3.6** For roadway surfaces, the surface of each layer shall be substantially free from waves or irregularities. The final surface, including pavement repair limits, shall not vary from a 10-foot (3 m) straightedge, applied parallel to the centerline, by more than 1/8 inch (3 mm). Spalled areas shall be repaired using an approved plant mix bituminous pavement commercial mix. The texture produced for the finished pavement shall be a grid surface with discontinuous longitudinal striations meeting the approval of the engineer. The milling shall produce a serviceable riding texture with no objectionable noise level.

**622.10.3.7** Existing shoulder material shall be removed as necessary to ensure no ponding of water on the driving surface after the milling operation.

**622.10.3.8** Care shall be exercised not to damage existing concrete pavement.

**622.10.3.9** Loose material on roadway surfaces not picked up by the milling machine shall be swept or broomed and picked up immediately behind the milling operation, except, in areas with earth or stabilized aggregate shoulders, small amounts of loose material not picked up by the milling machine may be swept to the shoulders as approved by the engineer. Loose material on bridge deck surfaces not picked up by the milling machine shall be swept and removed from the bridge deck immediately behind the milling operation.

**622.10.3.10** All milled material from the project shall remain the property of the Commission and shall be stockpiled as designated in the contract.

**622.10.3.11** The contractor shall apply pavement marking as required in the plans through the limits of milling of roadway surfaces in accordance with [Sec 620.40](#).

**622.10.4 Method of Measurement.** Measurement for removal of the existing pavement surface will be computed to the nearest square yard (square meter). Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in contract quantity. The correction will be added to or deducted from the contract quantity.

**622.10.5 Basis of Payment.** The accepted quantity of removal of existing surface will be paid for at the contract unit price. No direct payment will be made for loading, hauling, stockpiling or disposing of milled material, repairing spalled areas, placing and removing

temporary bituminous wedges around manholes, utility valves or other appurtenances, applying pavement marking, or other items incidental to completion of the work.

## **SECTION 622.20 COLDMILLING PAVEMENT FOR A DRIVING SURFACE**

**622.20.1 Description.** This work consists of improving the profile, cross slope or texture of existing pavement surface for the purpose of rut removal or retexturing. The finished profile shall provide a smooth riding surface, free from gouges, and shall have a uniform textured appearance.

**622.20.1.1** The operation shall produce a serviceable riding surface texture with no rutting or excessive noise level and a constant drainable cross-section. The contractor shall be knowledgeable of the equipment capabilities and is advised that the texture specified may not be obtainable at high production speeds.

**622.20.1.2** The specific location and description of work to be performed shall be as described in the contract. The locations may be field adjusted in length by the engineer, not to exceed 1/4 mile (0.5 km) for any one location and provided the total area for all locations is not changed, without change in payment. All specified locations shall be milled.

**622.20.1.3** Contractors shall make their own conclusions concerning the quantity of material to be removed. The actual depths of milling will vary due to rut depths, drainage and profile requirements.

**622.20.2 Equipment.** Equipment for profiling and removing the pavement surface shall be in accordance with [Sec 622.10](#). In addition, the following requirements shall apply.

**622.20.2.1** The milling drum shall have equally spaced teeth with a minimum of 60 per foot (1 per 5 mm) of drum width, in a minimum of two equally spaced flights. The minimum drum cutting width shall be 12 feet (3.6 m).

**622.20.2.2** The carbide cutting teeth shall be uniform in diameter, with a uniform length of  $\pm 0.02$  inch ( $\pm 0.5$  mm). In addition, the tooth holder blocks shall be uniform and not vary the cutting radius of the mandrel by more than  $\pm 0.02$  inch ( $\pm 0.5$  mm).

**622.20.2.3** Broken teeth shall be replaced immediately and may be corrected by replacing the individual tooth, provided the replacement tooth is matched to within  $\pm 0.02$  inch ( $\pm 0.5$  mm) of the adjacent teeth length. This procedure is not to be used to avoid changing the set of teeth as a unit, when needed to produce the required surface texture.

### **622.20.3 Construction Methods.**

**622.20.3.1** The pavement surface shall be removed to the depth as directed by the engineer and as described in this specification.

**622.20.3.1.1 Rut Removal.** Removal of material for rut removal shall be to the approximate depth of the bottom of the wheel rut in the lane being milled. The bottom of the rut should be textured, but only minimal material removed. Milling shall be done in an approximate lane width, but may start to the right of the centerline in the approximate left wheelpath, extending into the shoulder to allow drainage, leaving the existing centerline marking in place.

**622.20.3.1.2 Texturing.** Removal of material for surface texturing shall be done for the full lane width, to the depth needed in order to texture all of the described areas.

**622.20.3.2** After the proper combination of mandrel speed and forward speed have been established to produce the required texture, the daily operation is to be uniform and continuous for other than repair or emergency operations. It shall not be halted to load or unload trucks, or take on water.

**622.20.3.3** The pavement milling operations shall be regulated by an automatically controlled grade leveling and slope control device. The device shall provide control for producing a uniform surface to the established grade and a cross slope conforming to the requirements of the typical section. The device shall also be equipped with the necessary controls to permit the operator to adjust or vary the slope as directed by the engineer.

**622.20.3.4** The entire surface shall be textured, substantially free from waves or irregularities, and shall not vary from a 10-foot (3 m) straightedge, applied parallel to the centerline, by more than 1/8 inch (3 mm). There may be occasional exceptions where the bottom of a wheelpath may not be textured, in order to maintain an acceptable profile. Spalled areas shall be repaired using an approved bituminous patching material.

**622.20.3.5** The texture produced for the finished pavement shall be a uniform surface with longitudinal striations. There shall be a maximum lateral distance of 0.2 inch (5 mm) between adjacent longitudinal striation mark lines. The longitudinal distance from the center of a strike mark to the center of the next successive strike mark in line shall not exceed 5 inches (125 mm). The longitudinal successive strike marks shall approximate a continuous grooved line. The difference between the high and low of the surface texture shall be approximately 1/16 inch (2 mm).

**622.20.3.6** The pavement surface shall be removed and milled around and over appurtenances such as manholes or utility valves or within the limits of the work as directed by the engineer. Any damage to appurtenances by the milling and removal operation shall be the responsibility of the contractor to correct.

**622.20.3.7** Material adjacent to the lane being milled shall be removed as necessary to provide a smooth transition and to ensure no ponding of water on the driving surface after the milling operation. There will be no pay for additional milling width beyond lane width as required for drainage. Removal in the traffic lanes shall be with the same equipment, providing the same texture. Removal of shoulder material may be with other milling equipment, meeting the engineer's approval.

**622.20.3.8** Loose material not picked up by the milling machine shall be swept or broomed and picked up immediately behind the milling operation. If required by the engineer, the finished surface shall be wetted just prior to returning to traffic in order to reduce traffic visibility problems due to dust.

**622.20.3.9** All milled material from the project shall remain the property of the Commission and shall be stockpiled as designated in the contract.

**622.20.3.10** All milling shall be completed at each location before milling is started at the next location.

#### **622.20.4 Traffic Control and Marking.**

**622.20.4.1** Handling traffic shall conform to Division 100, General Provisions, and specifically as follows.

**622.20.4.2** The contractor shall not sign work areas for more than a maximum of one-half day's run. Only one work area shall be closed at a time. Signing shall be in accordance with the latest version of *Missouri Standard Plans for Highway Construction* and specifically as indicated on the traffic control plan.

**622.20.4.3** The contractor shall maintain traffic over the existing pavement. At least one lane and the adjacent shoulder shall be open to traffic at all times.

**622.20.4.4** Entrance and exit traffic shall be allowed at all times at interchanges, as designated on the traffic control plan, except for short periods of time as approved by the engineer for the purpose of moving equipment across the pavement.

**622.20.4.5** At the end of the work day, existing advanced warning signs and cones shall be removed and traffic shall be allowed to drive on the milled surface.

**622.20.4.6** A shadow truck shall be positioned properly with respect to the work. This truck shall have an attached truck mounted attenuator (TMA) and flashing arrow panel. The flashing arrow panel mounted on the shadow truck shall operate in a flashing caution mode for work along the main roadway. The flashing caution mode shall consist of simultaneous flashing lights in each corner of the arrow panel and shall not represent in any way, an arrow or chevron.

**622.20.4.7** Removed edge striping next to a shoulder is not required to be replaced by the contractor, unless otherwise noted in the plans. Any other pavement marking removed by the milling is to be replaced in accordance with standard specifications or other provisions of the contract.

**622.20.4.8** All expenses incurred by the contractor by reason of compliance with the above traffic requirements shall be considered as included in and completely covered by the unit bid price for the various items of work included in the contract. Any additional signs shall be furnished entirely at the contractor's expense. There will be no direct pay for the relocation of any signs.

**622.20.5 Method of Measurement.** The roadway lane width will be assumed for computing milling quantities. Measurement for removal of the existing pavement surface will be computed to the nearest square yard (square meter). Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in contract quantity. The corrections will be added to or deducted from the contract quantity.

**622.20.6 Basis of Payment.** The accepted quantity of removal of existing pavement surface will be paid for at the contract unit price. No direct payment will be made for loading, hauling, stockpiling or disposing of milled material, repairing spalled areas, temporary pavement marking or other items incidental to completion of the work. Traffic control shall be paid for at the accepted unit bid price for the items included in the contract.

## **SECTION 622.30 DIAMOND GRINDING CONCRETE PAVEMENT**

**622.30.1 Description.** This work consists of grinding concrete pavement to provide good riding characteristics, a surface texture and proper drainage. The finished surface shall be in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer.

**622.30.2 Equipment.** The grinding equipment shall be a power-driven, self-propelled machine specifically designed to grind and texture concrete pavement using diamond blades.

The effective wheel base of the machine shall be long enough to minimize vertical fluctuations. The equipment shall be of a size that will grind a strip at least 3 feet (1 m) wide. The equipment shall be capable of grinding the surface without causing spalls at cracks, joints or other locations.

#### **622.30.3 Construction Requirements.**

**622.30.3.1** The construction operation shall be scheduled and proceed in a manner that produces a uniform finished surface. Auxiliary or ramp lane grinding shall transition from the edge of the mainline as required to provide drainage and an acceptable riding surface. Grinding of bridge decks will not be required unless otherwise specified in the contract.

**622.30.3.2** If pavement undersealing is required, it shall be completed prior to any grinding.

**622.30.3.3** Grinding shall be accomplished in a manner that eliminates joint or crack faults and provides drainage by maintaining a constant cross-slope between grinding extremities in each lane. A tolerance not to exceed 1/16 inch (2 mm) will be allowed for adjacent sides of joints and cracks, except that under no circumstances shall the grinding depth exceed 3/4 inch (20 mm) from the top of the original surface. When grinding across faulted joints, a minimum of a 20 foot (6 m) transition onto the approach side slab shall be used.

**622.30.3.4** The transverse slope of the pavement shall conform to the typical section shown on the plans and shall have no depressions or misalignment of slope greater than 1/4 inch in 12 feet (2 mm/m) when measured with a 12-foot (3.6 m) straightedge placed perpendicular to the centerline. Areas of deviation shall be reground. Straightedge requirements do not apply across longitudinal joints or outside the ground area.

**622.30.3.5** As soon as practicable after grinding, the surface will be straightedged longitudinally by the engineer and all variations exceeding 1/8 inch in 10 feet (1 mm/m) will be plainly marked. Areas of deviation shall be reground.

**622.30.3.6** Substantially all of the pavement surface shall be textured. Extra depth grinding to eliminate minor depressions in order to provide texturing on 100 percent of the pavement surface will not be required.

**622.30.3.7** The grinding process shall produce a final pavement surface that is true to grade and uniform in appearance with a longitudinal line type texture. The line type texture shall contain parallel longitudinal corrugations that present a narrow ridge corduroy type appearance. The peaks of the ridges shall be approximately 1/32 inch (0.8 mm) higher than the bottoms of the grooves with approximately 55 evenly spaced grooves per foot (305 mm), measured perpendicular to the centerline.

**622.30.3.8** The contractor shall remove and dispose of all residue from the grinding in a manner and location acceptable to the engineer. Slurry or residue shall be removed from the pavement surface as soon as practicable and shall not be allowed to encroach on open lanes.

**622.30.3.9** No overnight lane closures shall be done for grinding operations.

**622.30.4 Traffic Control and Marking.** Traffic control and marking shall be in accordance with [Sec 622.20](#).

**622.30.5 Method of Measurement.** Measurement will be made to the nearest square yard (square meter). Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity.



**622.30.6 Basis of Payment.** The accepted quantity of ground pavement surface will be paid for at the contract unit price per square yard (square meter) for diamond grinding concrete pavement.

## SECTION 623

### CONCRETE BONDING AND EPOXY MORTAR

#### SECTION 623.10 CONCRETE BONDING COMPOUND

**623.11 Description.** This work shall consist of surface preparation and the furnishing and application of concrete bonding compound to be used to bond plastic concrete mortar to hardened concrete as shown on the plans.

**623.12 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Concrete Bonding Compound	<a href="#">1039.1</a>

#### 623.13 Construction Requirements.

**623.13.1 Surface Preparation.** The surface of the hardened concrete to which the plastic concrete mortar is to be bonded shall be thoroughly cleaned by sand blasting, wire brushes, hammers or other methods so that all loose and unsound concrete is removed and only sound concrete remains. The areas to be bonded shall be surface dry and all dust and loose particles removed by air jets prior to application of the bonding agent.

**623.13.2 Application.** The bonding agent shall not be applied when either the air or surface temperature is 60 F (15 C) or below.

**623.13.2.1** The two components shall be thoroughly mixed in the ratio and in accordance with the instructions shown on the containers. The two components may be warmed with indirect heat to temperature of 90 to 100 F (32 to 38 C) to reduce the viscosity. Under no circumstances shall any solvent be added to the compound.

**623.13.2.2** The mixed bonding agent shall be applied with a moderately stiff bristle brush and thoroughly worked into the hardened concrete surface. The thickness of application shall be an average of 20 to 25 mils (0.5 to 0.6 mm). If the concrete absorbs the bonding agent, another coat shall be applied.

**623.13.2.3** The plastic concrete or mortar shall be placed while the bonding agent is still tacky. If there is a delay in placing the plastic concrete or mortar and the bonding agent becomes tack free, another coat of bonding agent shall be applied.

**623.14 Basis of Payment.** No direct payment will be made for the furnishing of material, surface preparation or application.

#### SECTION 623.20 EPOXY MORTAR

**623.21 Description.** This work shall consist of surface preparation and the furnishing and application of epoxy mortar as shown on the plans.

**623.22 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Low Viscosity Epoxy	<a href="#">1039.2</a>

**623.22.1** Sand for mortar shall be an approved silica aggregate such as quartzite sand (Ottawa sand or equal). The sand shall be clean, dust free, dry (2 percent maximum moisture), bagged and shall conform to the following requirements:

(a) Chemical Analysis (Average Quarry Run):

Silicon Dioxide, percent, min	98.80
Aluminum Oxide + Titanium Dioxide, percent, max	0.85
Iron or Ferric Oxide, percent, max	0.10
Sodium Oxide, percent, max	0.10
Potassium Oxide, percent, max	0.20

(b) Physical Properties:

Specific Gravity	2.60-2.70
Loss on Ignition at 1000 C	0.08-0.16
Melting Point, degrees F (C)	3049-3400 (1676-1871)
Weight per cubic foot (Mass per m <sup>3</sup> ), loose, lb (kg)	75-95 (1201-1521)
Hardness-Moh's Scale, min	7
Voids (loose), percent	30-50

(c) Gradation:

Sieve Size	Percent Passing
No. 16 (1.18 mm)	100
No. 30 (600 µm)	97-100
No. 50 (300 µm)	5-35
No. 100 (150 µm)	0-2
No. 200 (75 µm)	0-0.4

The contractor shall furnish a certification in triplicate to the engineer certifying that the sand supplied conforms to all requirements specified. The certification shall include or have attached typical test results for all specified properties.

### **623.23 Construction Requirements.**

**623.23.1 Surface Preparation.** The surfaces to which the epoxy mortar is to be applied shall be free of oil, solvents, grease, dust, bitumen, dampness, loose particles and foreign matter. A large size commercial vacuum cleaner, or an air jet or both shall be used to remove dust and other particles just prior to placing the mortar. If an air jet is used, care shall be taken to avoid deposit of oil by the air pump.

**623.23.2 Application.** The epoxy mortar shall be prepared and placed when the weather is dry and the air temperature is above 70 F (20 C) but not higher than 95 F (35 C). The engineer may permit placement when the mix temperature and the surface temperature are above 60 F (15 C) and the air temperature is steady or rising.

**623.23.2.1** The mortar shall be 3.25 parts sand to one part low viscosity epoxy, by volume.

**623.23.2.2** The contractor shall estimate the time required to complete an area to be patched or leveled and the volume of material needed, and the contractor shall mix only the number of containers of material that can be placed in 20 to 40 minutes depending on the temperature.

**623.23.2.3** The two components of the low viscosity epoxy shall be thoroughly mixed in the ratio and in accordance with the instructions shown on the containers. Mixing shall be done with a special paddle designed for the purpose and driven by a low speed electric drill (500 to 600 rpm) or other approved mixing equipment. The mixing shall continue for two to three minutes or as required to obtain uniformity.

**623.23.2.4** When the low viscosity epoxy material has been thoroughly mixed, sand shall be added gradually while mixing continues, and after the proper quantity of sand has been added, the mixing shall continue for one to two minutes until the mixture is uniform.

**623.23.2.5** The areas to be patched or leveled shall be thoroughly primed with an application of neat low viscosity epoxy. After the area is primed, the mortar shall be placed and struck off to grade. The surface shall have a rough finish equal to that of a portland cement concrete deck.

**623.23.2.6** The patched or leveled area shall be protected during the curing period to prevent damage. The length of time required for curing will vary with temperature. The contractor shall be acquainted with information from the epoxy resin manufacturer relative to normal curing periods which can be expected at various ambient temperatures. Under no circumstance shall curing be hastened by direct flame application; but approved types of radiant heating systems may be used.

**623.24 Safety Precautions.** Epoxy resin compounds are toxic and the solvents are flammable. The contractor shall take due precautions to protect workers from the hazards of handling this material.

**623.25 Basis of Payment.** No direct payment will be made for the furnishing of material, surface preparation or application.

## SECTION 624

### GEOTEXTILE CONSTRUCTION

**624.1 Description.** This work consists of installation of geotextile for use in subsurface drainage, in erosion control, as a permeable separator or as otherwise specified.

**624.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Geotextile	<a href="#">1011</a>

#### 624.3 Construction Requirements.

**624.3.1** Areas on which geotextile is to be placed shall be reasonably smooth and free from mounds, windrows, debris or projections. Geotextile shall be placed in a manner to minimize wrinkles or creases in the material. When used for erosion control or to separate soil and granular material, geotextile shall be placed loose to the contour of the ground so as to be free to adjust to minor indentations and protrusions as rock or fill is placed against or over the material but secured sufficiently to preclude sliding or displacement during fill placement and under traffic. Geotextile shall be secured in place as necessary to perform the work with steel pins or by other suitable means.

**624.3.2** Lengths and widths of geotextile shall be chosen to minimize the required number of overlaps or seams. Adjacent rolls or strips of geotextiles shall either be sewn in accordance with recommendations of the manufacturer to meet seam strength requirements of AASHTO M 288, or overlapped.

**624.3.2.1** Overlaps shall be sufficient to prevent openings in the geotextile coverage as a consequence of subsequent filling operations and shall meet the following minimum requirements: 18 inches (450 mm) overlap on slopes 3:1 (1:3) or flatter; 24 inches (600 mm) on slopes steeper than 3:1 (1:3); 36 inches (900 mm) if placed underwater or on soft, yielding ground which, in the opinion of the engineer, ruts excessively under construction traffic; 12 inches (300 mm) when used to cover structural joints or drain pipes; and equal to the trench width, when used to line drainage trenches unless otherwise shown on the plans.

**624.3.2.2** Strips installed horizontally on slopes shall be overlapped upslope over downslope. Strips placed transverse to channel slopes shall be overlapped in the direction of flow. If a preformed "sock" is not used to cover pipe embedded in sand, the pipe shall be wrapped one and one-half times, tied or otherwise secured at intervals as required to maintain the integrity of the overlap and laid in the trench with the exposed lap end oriented toward the bottom of the trench.

**624.3.2.3** Fill placement and spreading on geotextile shall not be performed against the direction of geotextile overlap.

**624.3.3** Traffic shall not operate directly on uncovered geotextile. Sudden stops, starts and turning motions shall be kept to a minimum unless at least two lifts of overfill are in place. Unless otherwise specified, the initial lift of overfill shall not be less than 8 inches (200 mm), loose measurement, in thickness or twice the maximum particle size, whichever is greater.

**624.3.4** Damaged or punctured geotextile shall be replaced or patched to the satisfaction of the engineer. Patches may be sewn or overlapped. Unsewn patch overlaps beyond the area of damage shall exceed roll overlap requirements of this section by at least 12 inches (300 mm).

**624.3.5** Type 3 (Erosion Control) geotextile shall be protected from damage due to the placement of large rock by limiting the height of drop of the material to no greater than three feet (900 mm). In addition, if a Class B geotextile is used, either a cushioning layer of sand shall be placed on top of the geotextile or a zero drop height shall be utilized to place the rock. Regardless of the required placement technique, the contractor shall demonstrate that the placement technique will prevent damage to the geotextile. Placement of material shall begin at the toe and proceed up the slope.

**624.3.6** When placed behind wall panels or facing elements, geotextile shall be installed and secured in a manner proposed by the contractor and approved by the engineer such that migration of fines is controlled while allowing free drainage.

**624.3.7** Drainage trenches to be lined with Type 1 (Subsurface Drainage) geotextile shall be prepared with smooth sides and bottoms. The geotextile shall be placed to conform loosely to the shape of the trench and laid back on either side of the trench to allow for placement of aggregate backfill and pipe and for backfill compaction which shall be done in a manner to prevent damage to the geotextile. After compaction, the geotextile shall be lapped over the completed installation trench width or as shown on the plans.

**624.3.8** The U. S. Standard sieve number corresponding to the apparent opening size (AOS) shall not exceed 100 (150  $\mu$ m) for geotextile used in contact with any soil with more than 50 percent passing the No. 200 (75  $\mu$ m) sieve, nor shall it exceed 70 when used between any two dissimilar granular material, less than 50 percent passing the No. 200 (75  $\mu$ m) sieve, or to control movement of fines from a granular backfill through structural joints or into a drain pipe.

**624.3.9** During shipment and storage, geotextiles shall be protected from direct sunlight, ultra-violet rays, temperatures greater than 140 F (60 C), mud, dust and debris.

**624.4 Method of Measurement.** Geotextile used for lining drain trenches, wrapping drain pipe or for control of piping through structural joints and facing panels will not be separately measured and paid for, but will be considered as incidental and included in the unit price for the drain or structure. Geotextiles used for other purposes will be measured to the nearest square yard (square meter) of surface area covered without regard to any overlap.

**624.5 Basis of Payment.** The accepted quantity of geotextile will be paid for at the unit price included in the contract for the specific item. No direct payment will be made for securing pins or other incidental items.

## SECTION 625

### UNDERSEALING PAVEMENT

**625.1 Description.** This work shall consist of stabilizing portland cement concrete pavement by furnishing, hauling and pumping a grout mixture of cement, fly ash and water under the concrete slab. This work shall be completed after any required pavement repair and prior to the placement of any new overlay material.

#### **625.2 Material.**

**625.2.1** The materials used in grouting shall consist of a mixture of portland cement, fly ash and water proportioned as specified or directed by the engineer. Materials shall meet the following requirements:

Item	Section
Fly Ash	<a href="#">1018</a>
Cement, Type I, II or III	<a href="#">1019</a>
Water	<a href="#">1070</a>

**625.2.2** Cement and fly ash shall be stored in suitable weather-proof buildings, silos or by other approved methods which will protect the materials from dampness.

#### **625.3 Construction Requirements.**

**625.3.1 Weather Limitation.** Grouting shall not be performed when the air temperature is below 40 F (5 C), when the subgrade is frozen, when the subgrade contains an abnormal amount of moisture from recent rainfall as evidenced by standing water on the pavement or in joints or cracks, or when in the judgment of the engineer satisfactory results are not being obtained.

**625.3.2 Grout.** Grout for filling voids beneath the pavement shall be composed of cement, fly ash, water and, if necessary, admixtures. Grout shall meet the following minimum requirements: (1) Flow cone efflux time shall be 10 to 16 seconds as determined in accordance with ASTM C 939. (2) The grout shall consist of not less than one part cement by volume to three parts fly ash by volume and shall have a minimum design strength at minimum efflux time of 600 psi (4.1 MPa) at seven days as determined in accordance with the applicable portions of ASTM C 942, with the exception that storage of compressive specimens after 24 hours shall be placed in a 100 percent humidity cabinet. Preparation of grout shall be performed in accordance with ASTM C 938 with the following exceptions: (a) Mixing shall be performed with a commercial type blender operating at approximately 15,000 revolutions per minute (rpm), (b) molding of specimens shall be delayed by the time designated in the contractor's mix design submittal. At least three weeks prior to the beginning of this work, the contractor shall submit to the engineer the proposed mixture. The submittal shall include the mix design, source and type of all materials, and independent laboratory testing of the grout showing one day, three day and seven day compressive strengths, efflux time, time of initial and final set by Gilmore needle in accordance with ASTM C 266 and time delayed to molding specimens after mixing grout. The time delayed between mixing and molding will be the maximum holding time allowed in the field and in no case shall exceed 60 minutes. Accompanying the mix design submittal shall be sufficient quantities of all mixture components to permit laboratory verification of the grout properties listed herein.

Approximately 10 pounds (5 kg) of portland cement and 30 pounds (14 kg) of fly ash are required.

**625.3.3 Measurement of Materials.** The cement and fly ash for underseal grout shall be measured by weight (mass) or volume. The quantity of cement and fly ash to be used shall be calculated from the proportions specified by the engineer. Batches which do not contain the proper quantities of materials shall be wasted at the contractor's expense. Personnel, scales and equipment necessary for calibrating the proportioning devices and for verifying the accuracy of proportions shall be furnished by the contractor and shall be available at all times. The equipment shall include standard 50-pound (20 kg) test weights equivalent to 20 percent of the net load capacity of the scales, to the nearest greater 50-pound (20 kg) increment. However, not more than 20 weights will be required. All equipment shall be calibrated by the contractor in the presence of and subject to the approval of the engineer. Verification of the accuracy of the scales and other dispensing methods may be required at any time deemed necessary by the engineer, but will be performed at least once each day of operation.

**625.3.3.1** Any admixtures used shall be incorporated and mixed in the grout mixture in accordance with the admixture manufacturer's recommendations and as approved by the engineer. Admixtures may be added by hand methods. Admixtures shall be measured within a tolerance of plus or minus three percent of the required quantity.

**625.3.3.2** Weight proportioning (Mass determination) equipment, accuracy, calibration and verification shall meet [Sec 501.3](#). Volume proportioning equipment, accuracy, calibration and verification shall meet [Sec 501.6](#).

**625.3.4 Grout Mixer.** The grout plant shall consist of a high-speed colloidal-mixing machine. The colloidal-mixing machine shall operated at a minimum speed of 800 rpm, maximum speed to 2000 rpm, creating a high shearing action and subsequent pressure release to make a homogeneous mixture. Mixed material shall not be held for more than the period designated in the contractor's mix design submittal. The mix design period shall not exceed 60 minutes. With permission of the engineer, grout that has lost fluidity may be re-tempered with water one time. Water used to wash the drum of the mixer shall not be used as mixing water.

**625.3.5 Deflection Testing.** When required, deflection testing shall be performed in accordance with MoDOT Test Method T64.

**625.3.5.1** All testing shall be performed between the hours of 4:00 a.m. and 9:00 a.m., unless otherwise directed by the engineer. The contractor shall stop testing if the slabs are beginning to lock-up. Tests shall not be performed during spring thaw conditions or when the subgrade is frozen.

**625.3.5.2** The contractor shall furnish and maintain four gauges on two gauge mounts, two gauges per mount, that are capable of detecting slab movement of 0.001 inches (0.025 mm). Gauges and mounts must be approved by the engineer prior to use. The contractor shall also furnish and maintain a vehicle having a dual-tire single axle with an 18,000 pound (8 Mg) single axle load. The contractor shall furnish a truck operator and necessary personnel to place and assist in operating the gauges.

**625.3.6 Grouting Operations.** In general, the hole pattern shall be as shown in the plans. The drilled holes shall be a maximum of 1 1/2 inches (38 mm) in diameter, drilled vertically and round. Holes shall be drilled with a minimum of break out at the bottom of the pavement. Break out in excess of 1 1/2 inches (38 mm) outside the hole diameter shall constitute a non-acceptable hole and will not be counted for payment. After the hole is drilled, it shall be



blown clean with air pressure. The engineer reserves the right to modify the hole pattern, but in no case shall there be less than two holes.

**625.3.6.1** The grout efflux time will be determined by the engineer, but shall be between ten to sixteen seconds. The grout efflux time shall be measured by performing flow cone tests in accordance with ASTM C 939. Seven day comprehensive strengths of the grout material shall be determined from 6 x 12 inch (152.4 x 304.8 mm) cylinders molded daily from the grout material being used. Grout material failing to meet specifications shall be rejected.

**625.3.6.2** The contractor shall furnish equipment and personnel necessary to measure pavement lift during grouting. The equipment shall be capable of detecting the lift of the pavement edge relative to the adjoining shoulder or the adjacent slab. The equipment shall have the capability of measuring movement to the nearest 0.001 inches (0.025 mm). The equipment shall measure lift relative to the reference points and be of a design satisfactory to the engineer. The lift gauge will be read and recorded by the engineer. Pavement raised in excess of 0.20 inch (5 mm) and cracked shall be replaced at the contractor's expense to such limits as directed by the engineer.

**625.3.6.3** A positive action pump capable of forcing grout through a drilled hole into voids and cavities beneath the pavement slab or treated base shall be provided. The injection pump shall have pressure capability of 50 to 250 psi (345 to 1725 kPa) when pumping a grout slurry mixed to a twelve second flow cone time. The injection pump shall be capable of continuous pumping at rates as low as 1 1/2 gallons (6 L) per minute or the system modified by adding a recirculating hose and by-pass valve at the discharge end of the system.

**625.3.6.4** The grout shall be injected under the pavement progressively through the previously drilled holes by means of a pressure distributor. The distributor unit shall be equipped with the necessary hoses, fittings and valves, including a satisfactory nozzle for injecting the grout under the pavement without undue leakage at the point of injection.

**625.3.6.5** Grouting shall begin at a low pumping rate and pressure. However, a short surge up to 200 psi (1380 kPa) can be allowed at the start, but this shall quickly drop below 100 psi (690 kPa) to a range of 30 to 50 psi (205 to 345 kPa). Pumping shall be stopped if the initial pressure does not drop, the pumping pressure increases, grout appears at any adjacent hole or longitudinal or transverse joint or crack, the pavement is raised 0.125 inches (3 mm) or more, or when a negative reading occurs.

**625.3.6.6** All drill tailings, spilled grout and other debris shall be cleaned up at the end of each working day or before the lane is opened to traffic. When adjacent lanes are open to traffic, provisions shall be made to prevent grout from encroaching onto the open lane or squirting onto passing vehicles.

**625.3.7 Placing of Permanent Plugs.** The permanent plug shall not be placed until grout material injected beneath the pavement achieves initial set (grout material in the injection hole has resistance when pressed with finger). If the pavement is not to be resurfaced, the drill holes shall be filled flush with the surface of the pavement using a fast setting sand and cement mixture approved by the engineer. The mortar for filling the holes shall be composed of one part cement and two parts fine aggregate, by volume, and only enough water to permit placing and packing of the mortar in the holes or an approved commercial pre-mixed rapid set mortar or concrete may be used. If the pavement is to be resurfaced, the drill holes may be plugged with mortar as described above or by using an approved square or cylindrical wood plug, 4 to 5 inches (100 to 125 mm) in length, pointed at the lower end, with the top drive flush with the existing pavement surface.

**625.3.8 Handling Traffic.** The contractor may use one lane of the pavement for the equipment necessary to perform the work. At least one-way traffic shall be maintained at all times.

**625.3.9 Opening to Traffic.** No traffic shall be allowed on the undersealed pavement until three hours after the end of pumping operations and after all drill holes have been plugged. Grout ejection caused by traffic will be cause for further delaying opening to traffic.

**625.4 Method of Measurement.**

**625.4.1** Holes drilled through the concrete slabs, at the locations shown on the plans or as directed by the engineer, and properly filled after undersealing will be counted.

**625.4.2** Cement will be measured to the nearest 1/10 ton (0.1 Mg).

**625.4.3** Fly ash will be measured to the nearest 1/10 ton (0.1 Mg).

**625.4.4** Measurement of testing for deflection will be per joint, crack or pavement repair patch per traffic lane in which testing is performed. Testing prior to undersealing and testing after undersealing will be measured separately.

**625.5 Basis of Payment.** The accepted quantities of drilled holes, portland cement, fly ash and deflection tests will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for water or any admixtures used in the grout.

## SECTION 626

### RUMBLE STRIPS

#### SECTION 626.10 BITUMINOUS RUMBLE STRIPS

**626.11 Description.** This work shall consist of constructing rumble strips in the bituminous shoulders as shown on the plans or as directed by the engineer.

#### **626.12 Equipment.**

**626.12.1** Rollers used to form the rumble strips shall meet the requirements of [Sec 403.12](#). The rollers shall be modified with an adjustable auxiliary steel wheel roller or may be self-propelled steel wheel rollers designed solely for the purpose of forming a rumble strip.

**626.12.2** The roller wheel shall have approximate half sections of solid steel bar or steel pipe welded to the face of the wheel with the rounded surface of the bar or pipe away from the wheel. The steel bar shall have a nominal 1 1/2-inch (40 mm) diameter. The steel pipe shall have a nominal 1 1/2-inch (40 mm) inside diameter decreased in cross section to provide a nominal 3/4-inch (20 mm) projection of the section when welded to the wheel. Each section of bar or pipe shall be 3 feet (900 mm) in length with a 6-inch (150 mm) longitudinal beveled transition on each end. The longitudinal centerline of each section shall be aligned with the center axis of the wheel to maintain equal pressure along the length of the section when in use. Sections shall be spaced at nominal 8-inch (200 mm) centers around the perimeter of the wheel.

**626.12.3** The rumble strip roller wheel shall be equipped with a guidance device to enable the operator to maintain proper linear and offset alignment.

**626.12.4** The rumble strip roller wheel shall have a system for moistening the wheel contact surface.

**626.12.5** Sections shall be replaced if deformed or excessively worn.

#### **626.13 Construction Requirements.**

**626.13.1** Rumble strip depressions shall be formed in the hot bituminous surface of the shoulder at 8-inch (200 mm) intervals following the last pass of the final roller. Each depression shall be a nominal 1 1/2-inch (40 mm) wide indentation, 3/4 inch (20 mm) deep and 3 feet (900 mm) in length, excepting the two 6-inch (150 mm) depth transition sections.

**626.13.2** Rumble strip depressions shall be formed in one pass of the roller. The bituminous temperature shall be such that depressions can be formed to the specified length and depth without unacceptable displacement or tearing of the bituminous mix.

**626.14 Method of Measurement.** Measurement will be made parallel to the centerline for the length of rumble strip constructed on each shoulder to the nearest 10 linear feet (1.0 m).

**626.15 Basis of Payment.** The accepted quantity of rumble strips will be paid at the contract unit price per 100 feet (5.0 m) and will be full compensation for all labor, equipment, material and incidental work necessary to construct the rumble strips.

## **SECTION 626.20 PORTLAND CEMENT CONCRETE RUMBLE STRIPS**

**626.21 Description.** This work shall consist of constructing rumble strips in the concrete shoulders as shown on the plans or as directed by the engineer.

**626.22 Construction Requirements.** The corrugations shall be formed in the plastic concrete at the optimum time so as to produce a neat and uniform finish. Forms and methods used to form the corrugations shall be approved by the engineer.

**626.23 Method of Measurement.** Rumble strips will be measured by the square yard (square meter). Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be added to or deducted from the contract quantity.

**626.24 Basis of Payment.** The accepted quantity of rumble strips will be paid at the contract unit price per square yard (square meter) and will be full compensation for all labor, equipment, material and incidental work necessary to form the rumble strips.

# **DIVISION 700**

## ***STRUCTURES***



## SECTION 701

### PEDESTAL PILES

**701.1 Description.** This work shall consist of constructing a cylindrical reinforced concrete shaft cast-in-place to serve as a pedestal pile foundation for a structure.

**701.2 Material.**

**701.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete	<a href="#">1036</a>

Pedestal piles shall be made of Class B concrete, and all material, proportioning, air-entraining, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#).

**701.3 Equipment.** Casing, if used, shall be a metal shell of ample thickness and strength to withstand stress and avoid distortion due to handling, the internal pressure of plastic concrete, and the external pressure of the surrounding earth and water, and shall be watertight. The inside diameter of the casing shall be equal to the diameter of the pile.

**701.4 Construction Requirements.**

**701.4.1** Excavation for a pedestal pile may be made by hand methods or with a power-driven boring machine as an open well, inside or through a casing, or any combination of these methods, and shall include excavating through whatever material is encountered. The elevations of the bottom of pedestal piles shown on the plans are approximate only and may be raised or lowered by the engineer depending upon the conditions encountered. The shaft shall be sunk vertically within a tolerance of one inch in 10 feet (8 mm/m). The bottom of the excavation shall be cleaned of all loose boulders and loose or scaly shale or rock. The pile shall be keyed or cast into the foundation material as directed by the engineer.

**701.4.2** Where soil conditions permit, the shafts for pedestal piles may be excavated without the use of casings. If the excavation reaches a point where caving conditions or ground water seepage is encountered, a construction method shall be employed which will prevent any caving that tends to make the excavation appreciably larger than the size of the pile. The contractor may install casings to facilitate construction of pedestal piles. Withdrawal of casings will not be required unless otherwise specified in the contract. Casings to be left in place shall be installed in such manner that there will be no voids between the earth and the casing. The casing shall not extend more than 12 inches (300 mm) below the top of satisfactory foundation material. No payment will be allowed for any concrete or other material required because of an oversize casing or oversize excavation. If the elevation of the top of pedestal pile is below ground level at the time of concrete placement, an oversize casing from ground elevation to a point below the top of the pedestal pile will be required to prevent caving of any material into the freshly placed concrete.

**701.4.3** After excavating is completed, and if specified by the engineer, the contractor shall install a temporary casing for the protection of personnel working in or inspecting the shafts and foundation material. Such casing shall be removed either before or during the placing of concrete. The shaft shall be dewatered for inspection of the foundation material. The

contractor shall provide fresh air ventilation, electric lights, suitable means of ingress and egress, and shall assist the engineer in making the required inspection of the shaft and foundation material. Test holes may be required by the engineer in accordance with [Sec 206.3](#) and will be paid for in accordance with [Sec 206.6.2](#).

**701.4.4** The reinforcing steel cage for the pedestal pile shall be completely assembled and placed as a unit for the full length of the pile prior to placing any concrete. The cage shall be supported by some positive method to prevent its displacement. Approved spacers shall be provided at intervals along the cage to ensure concentric positioning for the entire length. Additional reinforcement may be added to stiffen the cage at the contractor's option and expense.

**701.4.5** Concrete for the pedestal pile shall be placed as soon as practicable after the excavation has been completed and inspected. Concrete shall be placed through a suitable tube to prevent segregation of concrete material. The tube shall be of such construction that it will permit discharge and raising as the concrete placement progresses. If casings are to be removed, they shall be withdrawn as the concrete placement progresses. A 2-foot (600 mm) minimum head of concrete shall be maintained in the casing to prevent displacement of the fresh concrete by caving material. The concreting shall be a continuous operation except for the time interval necessary for retracting the casing. If the placing of concrete is delayed more than 45 minutes, or if any upward movement of concrete inside the casing occurs during the retraction, the pulling shall be stopped and that portion of the casing extending into the concrete shall be left in place. Casings to be removed shall be smooth and well oiled.

**701.4.6** If an excavation cannot be practicably dewatered for the placement of concrete, the engineer may authorize a portion of the concrete to be placed under water. Concrete which is placed under water shall be Seal concrete in accordance with [Sec 501](#). Concrete placed under water shall be carried to a height at least 2 feet (600 mm) above the bottom of the casing, and to a height sufficient to withstand the hydrostatic pressure. When this concrete has reached sufficient strength to withstand the hydrostatic pressure, the casing shall be dewatered and the remainder of the concrete placed in the dry.

**701.4.7** No piling shall be driven or boring performed, either by jackhammer or drilled caisson methods, within a radius of 20 feet (6 m) of concrete that has taken initial set and has not attained a compressive strength of at least 1500 pounds per square inch (10 MPa). Compressive strength will be determined by tests made in accordance with MoDOT methods.

#### **701.5 Method of Measurement.**

**701.5.1** Measurement will be made to the nearest 1/10 linear foot (0.1 m) of each pedestal pile in place. No direct payment will be made for excavation below the top of the pile, or for casings left in place.

**701.5.2** Reinforcing steel will be measured and paid for in accordance with [Sec 706](#). Additional longitudinal and horizontal reinforcement required to extend the length of the steel cage will be measured and paid for, but no payment will be allowed for reinforcement incorporated in any part of the work by the contractor for the contractor's convenience.

#### **701.6 Basis of Payment.**

**701.6.1** The accepted quantity of pedestal pile will be paid for at the contract unit price per linear foot (meter) for the diameter of pile specified.



**701.6.1.1** Payment for additional completed pile lengths in excess of the "longest pile" as hereinafter defined, up to a maximum of 8 feet (2 m), will be made at the contract unit price plus 25 percent.

**701.6.1.2** Any work necessary to extend the length of pedestal piles more than 8 feet (2 m) in excess of the "longest pile" as hereinafter defined will be paid for as changes in the work in accordance with [Sec 104.3](#).

**701.6.1.3** The "longest pile" for the purpose of additional payment will be the maximum length pile, regardless of diameter, shown on the plans for interior bents of all bridges included in the contract.

## SECTION 702

### BEARING PILE

**702.1 Description.** This work shall consist of furnishing and driving concrete, steel and timber piles to the bearing and penetration required, at the location shown on the plans.

#### **702.2 Material.**

**702.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete	<a href="#">1036</a>
Round Timber Piles	<a href="#">1050.5</a>
<b>Specification</b>	
Steel Strand	AASHTO M 203
Cast-In-Place Pile Shells (Thick Shell Type)	
Welded or Seamless Steel Pipe	ASTM A 252
Closure Plates	AASHTO M 183
Fluted Pipe	SAE-1010 or SAE-1015
Forged Steel Tips or Noses	SAE-1020
Structural Steel Pile	AASHTO M 183

**702.2.2 Precast Concrete Piles.** Precast concrete piles shall be manufactured of Class A-1 concrete to the shape and size shown on the plans or to an approved equivalent section. All material, proportioning, air-entraining, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#). Precast piles shall be straight, with a centerline variation of not more than 1/2 inch per 25-foot (1.6 mm/m) length of pile. Precast concrete piles shall be lifted and handled by a suitable bridle attached to the pile at points shown on the plans. Unless the concrete is steam cured in accordance with [Sec 703.3.17](#), removal of precast concrete from casting beds shall not begin for at least 48 hours after casting and not then until a compressive strength of 1500 pounds per square inch (10 MPa) has been attained. If the concrete is steam cured, removal shall not begin until a compressive strength of 1500 pounds per square inch (10 MPa) has been attained. Curing shall be continued for at least 24 hours after a compressive strength of 2400 pounds per square inch (17 MPa) has been attained. Precast piles shall not be transported or driven until at least 7 days after casting and then only if the compressive strength of 2400 pounds per square inch (17 MPa) has been attained. Compressive strength of concrete shall be determined by tests of standard cylinders made of concrete from the same batches and cured in the same manner as the piles.

**702.2.3 Precast-Prestressed Concrete Piles.** Precast-prestressed concrete piles may be furnished in lieu of precast concrete piles. They shall be manufactured in accordance with [Sec 705](#) using Class A-1 concrete. End anchors shall not be released until the concrete has attained a compressive strength of 4000 pounds per square inch (28 MPa) as determined by tests of standard cylinders made of concrete from the same batches and cured in the same manner as the piles.

**702.2.4 Cast-In-Place Concrete Piles.** Cast-in-place concrete piles shall consist of Class B-1 concrete cast in pre-driven metal shells. The metal shells shall conform to the shape, size and minimum shell thickness shown on the plans, or to an approved equivalent section. All material, proportioning, air-entraining, mixing, slump and transporting of concrete shall be in

accordance with [Sec 501](#). Metal shells driven with or without a core or mandrel shall be of sufficient thickness or shall be reinforced so that they will hold their original form without distortion after being driven. Metal pile shells shall be free from water, soil and other deleterious matter when concrete is cast in them. The contractor shall maintain on the job at all times prior to and during the filling of the shells, a light suitable for use in their inspection.

**702.2.5 Structural Steel Piles.** Structural steel piles shall be of the series rolled as H-bearing piles. They shall be of the size, weight and structural shape shown on the plans. Piles shall not have a camber or sweep in excess of 1/8 inch (10.4 mm) multiplied by the length of pile in feet (meters) divided by five. Steel piles shall be stored on platforms, skids or other supports at the site of the work and shall be supported at not more than 15-foot (4.5 m) intervals.

**702.2.6 Timber Piles.** Timber piles shall be pointed where required by soil conditions. If specified in the contract or authorized by the engineer, piles shall be shod with metal shoes of approved design. The points of the piles shall be shaped to secure an even uniform bearing on the shoes. Care after treatment of pile shall be in accordance with [Sec 1050.7](#).

**702.2.7 Pile Length.** The pile lengths shown on the plans are approximate. The contractor shall be fully responsible for the lengths the contractor furnishes for driving to obtain the specified bearing and penetration. Sub-surface investigations made by the Commission are for design purposes only.

**702.2.8 Test Piles.** Test piles shall be the same material and size as the permanent piles, except that if treated timber piles are specified for the structure, untreated timber test piles may be used if not driven in a permanent location. Test piles of precast concrete shall, in general, be driven in permanent position. Test piles shall be of such length as to permit driving the tips to an elevation 10 feet (3 m) below that indicated by plan lengths unless otherwise specified.

**702.2.9 Certifications.** For structural steel piles and thick shells for cast-in-place piles, the contractor shall furnish two copies of a certification from the pile manufacturer or fabricator setting out the designated specification with which the material furnished complies.

### **702.3 Equipment.**

**702.3.1 Concrete Testing Equipment.** Equipment for field determination of compressive strength of concrete shall be furnished by the contractor at the location of manufacture of precast and precast-prestressed piles. The testing machine may be of any mechanical or hydraulic type capable of applying and measuring the required load and shall comply with the accuracy tolerances and corrections specified in AASHTO T 67, Section 16.1 and Section 17. Approximately the last one-half of the load shall be applied at a rate of between 1200 and 3000 pounds per square inch (8 and 21 MPa) per minute. The contractor shall furnish a sufficient number of compression test cylinder molds of a type meeting the approval of the engineer. The contractor shall furnish sufficient personnel for cleaning and preparing reusable molds.

**702.3.2 Driving Equipment.** The contractor shall furnish pile driving equipment adequate for handling the length of pile to be placed in the leads and for driving the total length of pile to the tip penetration and bearing required. Piles shall be driven with power-driven hammers, or by a combination of power-driven hammer and water jets. Power-driven hammers are defined as hammers operated by steam, air or diesel power. For determining the energy per blow of diesel power hammers without a fully enclosed ram, 75 percent of the manufacturer's energy rating for the hammer will apply. If the contractor desires to check a diesel power hammer against an approved steam hammer on a specified type of pile at a particular site, the contractor may do so at no additional cost to the Commission, and the checked rating of the

diesel powered hammer will be used in determination of pile bearing values at that site. Diesel hammers which have a fully enclosed ram shall be equipped with a gauge and accompanying charts which evaluate the equivalent manufacturer's rated energy being produced under any driving condition.

**702.3.3 Leads.** Pile driver leads shall be constructed in such manner as to afford freedom of movement of the hammer, and they shall be held in position by guys or stiffener braces to ensure support to the pile during driving. Inclined leads shall be used for the driving of battered piles.

**702.3.4 Followers.** Followers may be used in the driving of piles only if approved in writing by the engineer. If a follower is used, one pile of every group of ten shall be driven without a follower to determine the available bearing value of the group.

**702.3.5 Water Jets.** Water jets used to aid in driving piles shall be sufficient in number to deliver a volume and pressure of water at the jet nozzles that will freely erode the material adjacent to the pile. The use of water jets shall be discontinued before the final penetration is reached, and the piles shall be driven to secure a final penetration of not less than 2 feet (600 mm) if the nature of the soil permits.

**702.3.6 Hammer Energy.** The minimum energy developed by hammer per blow shall not be less than shown in Table I.

<b>TABLE I</b>	
<b>Hammer Energy</b>	
<b>ENGLISH</b>	
Type of Pile	Minimum Hammer Energy Required per blow, foot-pound (ft-lb)
Precast Concrete	1.0 ft-lb/lb times the total pile weight in pounds but not less than 8000 ft-lb.
Steel Shells for Cast-In-Place	3.0 ft-lb/lb times the total pile weight in pounds, including mandrel if used, but not less than 8000 ft-lb.
Structural Steel	The largest of the following: (1) 3.0 ft-lb/lb times the total pile weight in pounds. (2) 225 ft-lb/ton times the pile bearing value in tons. (3) 7000 ft-lb.
Timber	8000 ft-lb.
<b>METRIC</b>	
Type of Pile	Minimum Hammer Energy Required per blow, Newton-meter (N-m)
Precast Concrete	3.0 N-m/kg (mass) times the total pile mass in kilograms but not less than 11,000 N-m.
Steel Shells for Cast-In-Place	9.0 N-m/kg (mass) times the total pile mass in kilograms, including mandrel if used, but not less than 11,000 N-m.
Structural Steel	The largest of the following: (1) 9.0 N-m/kg (mass) times the total pile mass in kilograms. (2) 35.0 N-m/kN times the pile bearing value in kN. (3) 9500 N-m.
Timber	11,000 N-m.

#### **702.4 Construction Requirements.**

**702.4.1** The contractor shall furnish and drive test piles at locations specified. Where required, test piles shall be driven full length, or to refusal, or to a capacity 50 percent greater than that shown on the plans. In all cases the test piles shall be driven to not less than the minimum tip elevation shown on the plans for permanent piles. Test piles shall be driven with the same type of equipment as will be used for driving the permanent piles. Before driving test piles, the excavation shall be completed to an elevation not more than 2 feet (600 mm) above the proposed grade at the point where a test pile is to be driven. Test piles not driven in a permanent location shall be cut off, or pulled and backfilled, as approved by the engineer.

**702.4.2** Foundation piles shall not be driven until after the excavation for the footing has been substantially completed. The heads of piles shall be protected against damage during driving. The procedure incident to the driving of piles, shall not subject them to excessive and undue abuse. Any pile broken or damaged by reason of internal defects or by improper driving, or driven out of its proper location shall be removed and replaced, or a second pile may be driven adjacent thereto if this can be done without detriment to the structure.

**702.4.3** Where piles are to be driven through more than 5 feet (1.5 m) of compacted embankment, which has been in place for less than five years, prebored holes will be required entirely through the embankment to the lowest elevation of the natural ground line adjacent to the embankment, or as shown on the plans. The holes shall be of a diameter not less than that of the pile. The space remaining around any type pile after it is driven shall be completely filled with sand or other approved material.

**702.4.3.1** Other locations where preboring for piles is required will be shown on the plans. At such locations, holes shall be prebored to the elevation specified prior to pile placement. The holes shall have a diameter not less than that of the pile and shall be large enough to avoid damage to the pile being driven through the hole in hard material. The size of the hole shall be approved by the engineer before preboring is started. Pilot holes of lesser diameter than the pile shall not extend below the pile tip. After the pile is placed in the hole and before driving begins, the space remaining around the pile shall be filled with sand or other approved material before and maintained full during the driving of the pile. The pile shall then be driven in accordance with the requirements of [Sec 702.4.11](#).

**702.4.4** Final position of piles shall be not more than 1/4 inch per foot (20 mm/m) from the vertical or from the batter line shown on the plans. The maximum variation of the head of the pile from the position shown on the plans shall be not more than 2 inches (50 mm), except that piles in footings entirely below the finished ground line may not vary more than 6 inches (150 mm). All piles pushed up by the driving of adjacent piles, or by any other cause, shall be redriven to required bearing and penetration. Improperly driven, broken or otherwise defective shells shall be removed and replaced, or otherwise corrected to the satisfaction of the engineer.

**702.4.5 Splices.** Extending and splicing of piles is not desirable and full length piles shall be driven wherever possible and practicable. The number of splices used shall be held to a minimum. If extensions and splices are permitted or required by the engineer, they shall be made as follows:

**702.4.5.1** All welding, including splicing of steel shells and structural steel piles, and support or reinforcing angles welded to steel piles, shall be in accordance with [Sec 712.3.3.7](#) and performed by a MoDOT certified field welder using properly dried low-hydrogen E7018 electrodes that have been protected from the elements to maintain the dry condition. The contractor shall be fully responsible for the adequacy of welds during driving. Steel shells for cast-in-place concrete piles shall be spliced as shown on the plans. Structural steel piles shall

be spliced with a butt joint as shown on the plans. The contractor will be permitted to furnish lengths of cast-in-place pile shells which incorporate not more than one splice per pile or structural steel piles which incorporate not more than one splice per pile for lengths up to and including 40 feet (12 m). Not more than two splices will be permitted in each structural steel pile furnished for lengths exceeding 40 feet (12 m). In preparation of piles prior to driving, the use of individual sections less than 8 feet (2.5 m) long will not be permitted. Additional field splices necessary to extend structural steel piles or cast-in-place pile shells to reach adequate bearing material shall be limited to one per pile, unless authorized by the engineer.

**702.4.5.2** Precast and precast-prestressed concrete piles driven below plan elevations shall be extended by build-up construction. The forms for extensions of concrete piles shall remain in place at least 24 hours. The extension shall be cured in accordance with [Sec 703.3.17](#) and the exposed surfaces shall be finished in accordance with [Sec 703.3.15](#).

**702.4.5.3** Timber piles driven below plan elevations shall be withdrawn and replaced by longer piles or, if approved in writing by the engineer, they may be spliced. If splices are permitted, they shall be of the butt-joint type. The added piece shall conform closely in diameter to that of the main pile at the point of splice. Piles shall be sawed square and the butt joints shall bear evenly over the entire surface. The joint shall be banded with a 4-foot (1.2 m) length of iron pipe at least 12 inches (300 mm) in diameter centered on the joint and held in position by 5/8-inch (16 mm) lag screws 6 inches (150 mm) long with three lag screws in the pile and three in the splice. The sawed and trimmed surfaces of treated piling shall be given two heavy brush coats of hot creosote or copper naphthenate before the splice is assembled.

**702.4.6 Cut-Offs.** Tops of all piles shall be cut off square at cut-off elevations. Pile tops which support timber caps or grillages shall conform to the plane of the bottom of the superimposed structure. The heads of all treated timber piles shall be given two coats of hot creosote or copper naphthenate, and in addition, trestle piles shall be covered with a protective cap made by applying a coat of hot roofing pitch and a sheet of 0.024 inch (0.610 mm) thick galvanized metal. The cap material shall measure at least 6 inches (150 mm) more in diameter than the diameter of the pile, and shall be bent down over the pile, and the edges neatly trimmed and secured with large head galvanized or copper nails.

**702.4.7 Protective Coatings.** Before the coatings are applied, the steel shall be thoroughly cleaned. Steel shells and structural steel piles in end bents shall be coated with a heavy coating of an approved bituminous paint applied for a length of 3 feet (1 m) below the bottom of the concrete cap. All exposed steel piles shall be coated with bituminous paint 3 feet (1 m) below and one foot (300 mm) above the finished ground line. All other exposed surfaces of steel shells and structural steel piles, including bracing, shall be painted in accordance with [Sec 712.12](#) using System G, if there is no pay item for paint included in the contract; and the specified system if the contract contains a pay item for paint. Protective coatings below the normal low water line will not be required.

**702.4.8** Concrete footings shall not be placed on cast-in-place piles until at least 12 hours after the last pile in the footing has been cast. No piling shall be driven within a radius of 20 feet (6 m) of concrete that has taken initial set and has not attained a compressive strength of at least 1500 pounds per square inch (10 MPa). Compressive strength will be determined by tests made in accordance with MoDOT methods.

**702.4.9 Static Load Tests.** The bearing value of piles shall be determined by actual load tests if specified or ordered by the engineer. The test shall consist of the application of a load placed upon a suitable platform supported by the pile, with suitable apparatus for accurately measuring the test load and the settlement of the pile under each increment of load. Hydraulic jacks with suitable yokes and pressure gauges may be used in lieu of the loaded platform. The

test load shall be applied to exert a uniform pressure over the pile being tested. Prior to the driving of the pile to be loaded, the contractor shall submit to the engineer plans for applying the test load. Sketches showing arrangement of apparatus for obtaining settlements and recovery measurements of the test shall also be furnished to the engineer. Two gauges shall be used to measure settlement and recovery of the pile loaded, and at least one gauge shall be used on each hold-down pile to measure uplift if the hold-down system of load application is used. All test loads shall be applied concentrically and shall be kept uniform by constant attention to load gauge readings and jacking applications. The driven pile shall not be disturbed for at least 24 hours prior to the application of any portion of the test load. The load shall be applied in 25 percent increments of the total load, allowing rest periods of six, twelve and six hours respectively between the increment of loading. The safe allowable load per pile shall be considered as 50 percent of that load which, after remaining in place for 48 hours, produces a permanent settlement not greater than 1/4 inch (6 mm), measured at the top of the pile. All test loads shall be removed at 30 minute intervals in the same increments specified for placing, and readings for recovery shall be taken just prior to the removal of each increment. If results of the load tests are not satisfactory, the engineer will make arrangements for such corrective changes as deemed necessary which may include redesign of the foundations. No compensation will be allowed for any delay or inconvenience caused by corrective changes or redesign.

**702.4.10 Dynamic Bearing Formulas.** The following formulas will be used as a guide to determine the safe bearing value of piles if static load tests are not required.

ENGLISH		
$P = \frac{2WH}{(S+0.1)}$	$\cdot \frac{2W}{(W+w)}$	*for single acting hammers.
$P = \frac{2E}{(S+0.1)}$	$\cdot \frac{2W}{(W+w)}$	*for double acting hammers and diesel powered hammers with enclosed rams and bounce pressure gauges.
$P = \frac{2(0.75E)}{(S+0.1)}$	$\cdot \frac{2W}{(W+w)}$	*for all other diesel powered hammers unless tested as specified in <a href="#">Sec 702.3.2</a> .
METRIC		
$P = \frac{1636WH}{(S+2.54)}$	$\cdot \frac{2W}{(W+w)}$	*for single acting hammers.
$P = \frac{167E}{(S+2.54)}$	$\cdot \frac{2W}{(W+w)}$	*for double acting hammers and diesel powered hammers with enclosed rams and bounce pressure gauges.
$P = \frac{167(0.75E)}{(S+2.54)}$	$\cdot \frac{2W}{(W+w)}$	*for all other diesel powered hammers unless tested as specified in <a href="#">Sec 702.3.2</a> .

\*The value of  $\frac{2W}{(W+w)}$  shall be considered unity if it exceeds one.

P	=	safe allowable bearing value in pounds (newtons).
W	=	weight (mass) of striking part of hammer in pounds (kilograms).
w	=	weight (mass) of pile and mandrel in pounds (kilograms).
H	=	height of fall in feet (meters).
E	=	manufacturer's rated energy in foot-pounds (joules) per blow at manufacturer's rated speed, or in case of a diesel hammer equipped with a bounce pressure gauge the actual energy shown by the gauge chart.
S	=	average penetration in inches (mm) per blow for 10 to 20 consecutive blows.

**702.4.10.1** The above formulas are applicable only if:

- (a) The piles are driven in a vertical position.
- (b) The hammer has an unrestricted fall.
- (c) The pile head is not broomed, crushed or splintered.
- (d) There is no appreciable bounce of the hammer after striking the pile.
- (e) The penetration is at a uniform or uniformly decreasing rate.

**702.4.10.2** For piles driven to a batter, the safe bearing value of the pile shall be taken as follows:

$$P_B = \frac{0.1(10-m)}{(1+m^2)} \times P$$

- $P_B$  = safe allowable bearing value in pounds (newtons) for batter pile.
- $m$  = the tangent of the angle of batter.
- $P$  = safe allowable bearing value in pounds (newtons) for vertical pile.

**702.4.11** Piles shall be driven to the minimum penetration indicated on the plans. If no minimum penetration is shown on the plans, piles shall have a tip elevation at least 10 feet (3 m) below the bottom of the supported footing or 10 feet (3 m) below the natural ground line, whichever is lower, unless specifically authorized otherwise by the engineer. Piles other than structural steel piles shall be driven to attain a bearing value not less than that shown on the plans, determined in accordance with [Sec 702.4.10](#). Structural steel piles shall in general be driven to practical refusal which is defined as a pile bearing value of 1.9 times the design bearing value. In general, timber piles shall not be driven to a bearing value in excess of 5 tons (45 kN), nor concrete piles to a bearing value in excess of 10 tons (90 kN), over the design bearing value.

#### **702.5 Method of Measurement.**

**702.5.1** Piles in place shall be the actual length of all piles, except test piles, measured to the nearest foot (0.5 m) for that portion of each pile that remains permanently in the structure.

**702.5.2** Test piles will be measured to the nearest linear foot (0.5 m) of pile authorized and driven.

**702.5.3** Precast and precast-prestressed concrete piles with built-up extensions will be considered single piles for measurement. No measurement will be made for the length of pile destroyed when making the extension.

**702.5.4** No measurement will be made for that excavation required to apply protective coatings. Measurement of prebored holes required under the provisions of [Sec 702.4.3](#) will be made to the nearest linear foot (0.5 m) of each hole specified or directed by the engineer. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.



**702.6 Basis of Payment.**

**702.6.1** The accepted quantity of bearing pile will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for incidental items necessary to complete the work unless specifically provided as a pay item in the contract. No direct payment will be made for painting exposed surfaces of steel shells, structural steel piles and bracing.

**702.6.2** Test piles will be paid for at the contract unit price. Test piles if driven and used as permanent piles in place will be paid for as test piles and not as piles in place.

**702.6.3** No payment will be made for any cut-offs.

**702.6.4** Loading test will be paid for at the contract unit price. Piles tested will be paid for as accepted bearing pile.

**702.6.5** Metal shoes where specified, will be paid for at the contract unit price.

**702.6.6** Payment for preboring as specified in [Sec 702.4.3](#) will be made at the contract unit price. No direct payment will be made for backfilling.

**702.6.7** If a splice is authorized to extend a structural steel or steel shell pile to reach adequate bearing material, the splice will be paid for if the total required in place pile length for each pile exceeds the plan length by more than 10 percent of the plan length. Splices, if authorized, will be paid for as an additional 8 feet (2.5 m) of pile in place at the contract unit price.

## SECTION 703

### CONCRETE MASONRY CONSTRUCTION

**703.1 Description.** This work shall consist of constructing culverts, bridges and other structures of concrete, and the manufacture, transportation and erection of precast concrete slab units for bridges.

#### **703.2 Material.**

**703.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Bearing Pads	<a href="#">1038</a>
Joints for Concrete Structures	<a href="#">1057.2</a>
Joint Sealing Material	<a href="#">1057.2.6</a>

All material, proportioning, air-entraining, mixing, slump and transporting of portland cement concrete shall be in accordance with [Sec 501](#) or [704](#), as applicable.

**703.2.2** Changes in sources of cement and aggregates will be permitted only with the written approval of the engineer. Aggregates of essentially the same characteristics, except as noted in [Secs 1005.1.4](#) and [1005.2.3](#), and cements resulting in concrete of the same color, shall be used in any individual unit of the structure. The superstructure is considered an individual unit of the structure unless otherwise shown on the plans.

**703.2.3** Concrete for precast slab units may be either Class A-1 or Class X concrete.

#### **703.3 Construction Requirements.**

**703.3.1 Falsework.** Falsework for concrete masonry construction shall be adequate to support and hold the forms true to lines, camber and grades shown on the plans. The contractor shall submit detailed plans for falsework, including supporting design computations. The engineer's acceptance of the plans will not relieve the contractor of the responsibility for obtaining satisfactory results. The falsework shall be constructed in general accordance with the submitted plans. The submittal of detailed falsework plans for small structures may be waived by the engineer. Falsework and forms for single and multi-span concrete frames and for continuous concrete slab and girder type bridges shall be provided for the full length of each continuous or monolithic unit and for the full width of the structure before starting concrete placement in that unit. Timber used in falsework shall be sound, in good condition, and free from defects which might impair its strength. Timber falsework piles shall be sound, reasonably straight, free from defects, and long enough to obtain the required bearing without splicing. They shall be accurately cut to the proper grade, and the use of shims or blocking shall be held to a minimum. Screw jacks shall be placed at approved locations to secure and maintain the required camber. Means shall be provided by the contractor for accurately determining settlement of the falsework while it is being loaded. The contractor shall furnish responsible personnel who shall correct the settlement by adjusting the jacks. The personnel shall be on duty at all times while the falsework is being loaded and until settlement ceases.

**703.3.2 Forms.** Forms for concrete shall be built true to the lines and grades specified, and be mortar-tight and of sound material adequate to prevent distortion during the placing and curing of concrete. All concrete shall be formed unless otherwise specified. A concrete pad of approved thickness may be used as a form for the unexposed bottom of end bent beams on piles. No direct payment will be made for the concrete pads. Form work plans, if required by the engineer, shall be submitted by the contractor before form work is started. If during or after placing the concrete, the forms sag or bulge, the concrete affected shall be removed, the forms realigned and new concrete placed. Construction camber to take care of shrinkage or settlement impairing the strength of the structure by the reduction of depth will not be permitted. The forms shall be designed for a fluid pressure of 150 pounds per cubic foot (for a fluid density of 2400 kg/m<sup>3</sup>) and, in addition, for a live load of 50 pounds per square foot (1.5 kPa) on horizontal surfaces and 30 pounds per square foot (1.5 kPa) on vertical surfaces for impact and vibration.

**703.3.2.1** Face lumber of forms for exposed surfaces of concrete shall have a smooth dressed surface free of loose knots, knotholes and other defects. The spacing of supports and the thickness of face lumber shall be adequate to prevent distortion due to the pressure of the concrete. Face lumber shall have a minimum nominal thickness of one inch (25 mm) for solid lumber or 5/8 inch (16 mm) for plywood. Form material shall be placed with horizontal joints. Triangular moulding, smooth on three sides and having 3/4 inch (19 mm) width on each of the two form sides, shall be used to bevel all exposed edges of the structure, except where special bevels are shown on the plans.

**703.3.2.2** Forms reused shall be in good condition. Form lumber which is unsatisfactory in any respect shall not be used.

**703.3.2.3** Design and construction of forms shall permit their removal without damage to the concrete. Cofferdam braces or struts which will extend through any exposed concrete section will not be permitted. Forms under copings and around offsets may be given a draft of not more than one inch per foot (83 mm/m) to permit removal without damage to the concrete. For narrow walls where access to the bottoms of the forms is not otherwise obtainable, an opening shall be provided so that chips, dirt, sawdust or other foreign material may be removed immediately prior to placing concrete.

**703.3.2.4** Interior forms for the top slab of box girder bridges, including their supporting joists and wales, may remain in place unless otherwise shown on plans.

**703.3.3** Form lining will be permitted and will be required for exposed curved surfaces. Liners shall be of plywood or of an approved composition board and shall be at least 1/4 inch (6 mm) thick.

**703.3.4** Fiber tubes for column forms above the ground line shall have a finish free of gaps or overlaps in the inside ply and shall be coated inside with a waterproofing material which will not stick or bond to or discolor the concrete surface of the column. Fiber tubes for column forms from 6 inches (150 mm) below the finished ground line down may show seams, shall be waterproofed and need not be removed.

**703.3.5** Metal forms shall meet all the requirements of wood forms in so far as applicable and shall not be used except with permission of the engineer. If required by the engineer, detailed drawings of the proposed metal forms shall be submitted for approval. If wood forms are to be used in combination with metal forms, form details shall be submitted for approval. Steel panels, or panels with metal frames and wood, which leave permanent impressions or ridges shall not be used except for concrete box culvert type structures and other non-exposed areas.

**703.3.6** Oiling of the inside of all forms will be required except for those having composition linings. The oil used shall be a light, clear paraffin base oil or other approved material which will not discolor or damage the exposed concrete surface. The coating shall be applied before placing reinforcing steel.

**703.3.7** Ties and spreaders and all metal appliances used inside of forms to hold them to correct alignment and location shall be so constructed that after removal of forms, the metal may be removed to a depth of at least one inch (25 mm) below the surface of the concrete. Metal tie rods used inside the forms where concrete will have an exposed surface shall be a type which will not produce a cavity at the surface of the concrete greater than 1 1/2 inches (38 mm) in diameter. Bolts and rods used as ties shall not be removed by pulling them through the concrete. Wire ties and pipe spreaders will not be permitted, and metal or wood spreaders which are separate from form ties shall be removed as concrete is being placed. A bolt-through method of supporting forms for massive substructure units may be used with the approval of the engineer. No form ties shall be embedded in concrete above the roadway surface on bridges except that coil ties and threaded rods may be permitted through the vertical face of the base and vertically through the top of barrier curbs. Coil ties and all metal to be embedded in barrier curbs shall be epoxy coated or galvanized.

**703.3.8** Cavities produced by the removal of metal tie rods shall be carefully filled with mortar composed of approximately one part cement to two parts sand. White cement shall be added to the mortar if necessary to obtain the required color. In order to reduce the shrinkage, no mortar shall be placed in the cavities until 45 minutes after the initial mixing. In lieu of the above, any approved non-shrinking, non-staining type of mortar may be used. After the cavities are filled, the surface shall be left smooth, even and uniform in color and texture. Tie rod cavities in surfaces against which backfill is to be placed shall be filled with mortar or an approved plastic compound meeting the requirements of [Sec 1057.3](#). Patching of tie rod cavities in the interior surfaces of box girders will not be required.

#### **703.3.9 Tubes for Voids.**

**703.3.9.1** Fiber tubes shall be properly designed for the use indicated and fabricated of spun-wound or laminated paper. The outside surface shall be waterproof. Tubes shall be stored under cover and kept off damp ground until ready for use. Distortion of the tubes shall be prevented during storage. The ends shall be covered with suitably designed caps which shall be mortar tight. If material used for capping tubes expands when moist, a preformed joint filler 5/16 inch (8 mm) thick shall be used around the perimeter of the caps.

**703.3.9.2** Steel tubes shall have a minimum thickness of 0.024 inch (0.610 mm) and shall be designed for the use indicated and fabricated to ensure against damage or excessive distortion in handling, storage and placing. The diameter of the tube shall be as shown on the plans with a tolerance of plus zero and minus 3/4 inch (19 mm). The ends of tubes shall be covered with suitably designed metal end caps which are mortar tight.

**703.3.9.3** Tubes for producing voids in concrete slab superstructures shall be accurately located in positions shown on the plans and shall be positively anchored to the joists carrying the floor forms. Anchors and ties shall be designed to leave a minimum of supporting material exposed in the bottom of the finished slab of the completed structure. Details of proposed anchorage and ties for the tubes shall be submitted for approval before work is started on the bridge superstructure. One 3/4-inch (19 mm) weephole shall be provided near each end of each tube. Weepholes shall be placed in straight lines parallel to bents. They shall extend through the forms and be kept open at all times. Tubes shall be protected from moisture and heat until concrete is placed. Distortion of tubes after placing of concrete shall not increase their vertical axis by more than 1/2 inch (13 mm).

**703.3.10** Falsework and form removal from under any structural concrete unit shall not be started until the concrete has attained at least the compressive strength shown in [Table I](#). The falsework support of all concrete spans of a continuous or monolithic series, shall be first released from the center of all spans, and shall proceed simultaneously from all span centers each way toward adjacent bents. Release shall be in such manner as to permit the concrete to gradually and uniformly take stresses due to its own weight (mass).

<b>TABLE I</b>	
<b>Class of Concrete</b>	<b>Compressive Strength psi (MPa), min</b>
B	2750 (19)
B-1	3000 (21)
B-2	3000 (21)
X	3000 (21)

Compressive strength will be determined by tests made in accordance with MoDOT methods.

**703.3.10.1** Except as provided in [Sec 703.3.17](#), forms for vertical surfaces of bridge superstructure shall be removed as soon as the concrete is self-supporting, generally within 24 hours after placement, to permit prompt patching of tie holes.

**703.3.11** The forms for precast slab units shall be placed on a rigid, level, smooth base and shall be sufficiently rigid in themselves that there will be no movement of the forms during the placing and the setting of the concrete. Unless the concrete is steam cured in accordance with [Sec 703.3.17](#), removal of non-prestressed precast slab units from casting beds shall not begin for at least 48 hours after the casting. In addition, whether cured by steam or other means, removal shall not begin until a compressive strength of 1500 pounds per square inch (10.5 MPa) for Class A-1 concrete, and 1200 pounds per square inch (8.3 MPa) for Class X concrete has been attained. Curing shall be continued for at least 24 hours after a compressive strength of 2400 pounds per square inch (16.5 MPa) for Class A-1 concrete, and 2000 pounds per square inch (13.8 MPa) for Class X concrete has been attained. Precast units shall not be transported or erected until at least 7 days after casting and then only if the stipulated strength for curing has been attained.

**703.3.11.1 Concrete Testing Equipment.** Equipment for field determination of compressive strength of concrete shall be furnished by the contractor at the location of manufacture of precast slab units. The testing machine may be of any mechanical or hydraulic type capable of applying and measuring the required load and shall comply with the accuracy tolerances and corrections specified in AASHTO T 67, Section 16.1 and Section 17. Approximately the last one-half of the load shall be applied at a rate of between 1200 and 3000 pounds per square inch (8 and 21 MPa) per minute. The contractor shall furnish a sufficient number of compression test cylinder molds of a type meeting the approval of the engineer. The contractor shall furnish sufficient personnel for cleaning and preparing reusable molds.

**703.3.12** Placing concrete in any unit of a structure shall not begin until preparations for placing and finishing are satisfactory to the engineer. Concrete shall be placed in the form in layers as near final position as practicable with minimum handling. Each placement shall be completed in a continuous operation with no interruption in excess of 45 minutes between the placing of contiguous portions of concrete. Where a finishing machine is to be used, it shall be moved over the area to be finished, immediately prior to placing concrete in any bridge deck pour, to facilitate checking reinforcement cover and slab thickness. This checking shall be made in the presence of the engineer and with the screeds in the finishing position. Placing

of concrete for bridge decks shall proceed uniformly for the full width of the placement. Once begun, placing of concrete in the superstructure of a continuous or monolithic series of spans shall proceed as rapidly as good construction practice will permit until all the concrete in that series is placed. Vibrators having a minimum frequency of 4500 impulses per minute shall be used to thoroughly consolidate the concrete in the forms and around the reinforcing steel. Sufficient vibrators shall be on hand to ensure continuous placement of the concrete without delay. They shall not be used for moving concrete from place to place nor shall they penetrate or disturb previously placed layers of concrete which have taken initial set. Vibration shall not be prolonged until it causes segregation of the material. Reinforcing steel protruding through transverse or longitudinal headers shall not be disturbed until the concrete is at least 24 hours old.

**703.3.12.1** Where placing operations involve dropping the concrete more than 5 feet (1.5 m), the concrete shall be deposited through vertical sheet metal or other approved pipes. These pipes shall be made in sections not to exceed 4 feet (1.2 m) long. In chutes, the velocity of the concrete shall be retarded by the use of baffles or chokers, or by the use of a series of short chutes to reverse the direction. Open troughs and chutes shall be either metal or metal-lined. Where concrete is placed in the interior of pneumatic caissons, it may be deposited through air locks or other approved devices, and the requirement of dropping the mixture not more than 5 feet (1.5 m) will be waived.

**703.3.12.2** Concrete shall be worked under and around the reinforcing steel without displacing the steel. Forms and reinforcing steel above concrete being placed and placing equipment shall be kept clean and free from coatings of hardened concrete. Water used for flushing the equipment shall be discharged clear of the concrete and forms.

**703.3.12.3** Concrete shall be placed around the tubes forming voids in slab spans using methods to prevent the displacement of the tubes. For tubes having an inside diameter greater than 14 inches (350 mm), the concrete shall be placed in three layers. The first layer shall extend from the floor forms up to a plane 1/4 tube diameter above the bottom of the tubes and the second layer to 3/4 tube diameter. For tubes 14 inches (350 mm) or smaller, the concrete shall be placed in two layers, with the lower layer extending to the middle of the tube. Each layer, after placing, shall be vibrated and allowed to settle before the next succeeding layer is placed, which layer shall be deposited while the concrete in the layer below is still plastic enough to permit intermixing the two layers by use of a vibrator.

**703.3.12.4** The sequence of placement of concrete for roadway slabs on a continuous series of spans will be shown on the plans together with the minimum rates of placement required for the basic sequence and for combinations thereof. The contractor shall observe the basic sequence of placement unless the contractor can demonstrate that the contractor can place and satisfactorily finish combined placements at the required rate. If the contractor wishes to alter the placing sequence or to combine units, the contractor shall submit a request for approval in writing.

**703.3.12.5** Concrete for substructure units shall be placed in the dry unless otherwise authorized by the engineer. If the supporting material at plan elevation of the bottom of a pile footing is not sufficiently stable to support the concrete it shall be stabilized, or the bottom of the footing shall be formed to adequately support the concrete. No direct payment will be made for the stabilizing of material or forming under pile footings.

**703.3.12.6** Depositing concrete under water will be permitted if provided for in the contract or upon written approval of the engineer. The concrete shall be placed by tremie bottom dump bucket or mechanically applied pressure. The tremie shall consist of a tube having a diameter of not less than 10 inches (250 mm) and shall be equipped with a hopper of suitable capacity.

The bottom dump bucket shall have a capacity of not less than 1/3 cubic yard (0.25 m<sup>3</sup>). The concrete shall be placed in its final position in still water and shall not be vibrated or disturbed after being deposited. Concrete placed under water and for seal courses shall be Seal concrete in accordance with [Sec 501](#).

**703.3.12.7** Conveying or pumping equipment shall have adequate capacity, be suitable for the intended work and be so operated as to produce a continuous stream of uniform concrete. It shall be arranged to prevent transmission of vibration to freshly placed concrete. The system through which the concrete is pumped shall be manufactured so that no aluminum parts will come into contact with the concrete.

**703.3.12.7.1** Equipment provided for conveying and placing concrete by mechanically applied pressure shall have adequate capacity and be suitable for the intended work. It shall be so operated as to produce a continuous stream of uniform concrete. The system through which the concrete is pumped shall be manufactured so that no aluminum parts will come into contact with the concrete.

**703.3.12.7.2** At the completion of concrete placement, the last concrete used from the pipeline shall be ejected in a manner that will prevent contamination or segregation of the concrete.

**703.3.12.8** Concrete used for filling cavities or crevices as authorized by the engineer and as required in [Sec 206.4.2](#) shall be Class B concrete. This concrete shall be unformed mass concrete placed separately from and prior to the placing of footing concrete.

**703.3.13** Construction and expansion joints in concrete masonry shall be located where shown on the plans except that in case of an unforeseen contingency, an emergency construction joint may be permitted. Surfaces of construction joints shall be roughened or scored unless shear keys are shown on the plans. The face edges of all joints shall be carefully finished, and feather edges shall be avoided. When the placing of concrete is temporarily discontinued, the concrete after becoming firm enough to retain its form shall be cleaned of laitance and other objectionable material, and shall be thoroughly wetted before placing new concrete. Contraction joints in floor slabs of truss bridges may be sawed. Waterstops and flashings as shown on the plans shall be continuous if practicable. If splices are shown on the plans or permitted by the engineer, they shall be watertight.

**703.3.13.1** Preformed sponge rubber expansion joint material shall be of the dimensions shown on the plans. Splices shall be held to a practicable minimum and shall be made by lacing with copper wire or soft-drawn galvanized steel wire. All joint material shall be securely stitched to one face of the concrete with No. 10 gage (2.588 mm) copper wire or No. 12 gage (2.692 mm) soft-drawn galvanized steel wire. Unless joint sealing is specified, the sponge rubber material shall be left exposed for its full length with clean and true edges.

**703.3.14** Riding surfaces shall be finished true to the alignment, grade, cross section and camber shown on the plans. These surfaces shall be finished by use of an approved mechanical finishing machine. On skewed structures the finishing machine shall be adjusted to finish the surface approximately parallel to the skew if the angle of skew exceeds 45° or if the angle of the skew exceeds 30° and the placement width divided by the span length equals or exceeds 0.8. Use of vibratory screeds will not be approved whether or not they are a part of the proposed finishing machine.

**703.3.14.1** Machine finishing shall be with an approved self-propelled mechanical finishing machine. The engineer may waive its use on isolated irregular shaped areas of the bridge surface. The finishing machine shall travel on adjustable rails or guides set to proper grade,

and supported outside the limits of the finished riding surface. Where a longitudinal joint is shown on the plans, the finishing machine rails or guides shall be placed as close as practical to the longitudinal joint. The rails shall be supported to limit the full operating load deflection between supports to 1/8 inch (3 mm) or less. They shall in general be placed parallel with the centerline of roadway or the longitudinal axis of the area to be finished. Where supports are so located that fresh concrete must be placed around them, the rails or guides shall be furnished in sections of 10 feet (3 m) or less and placed above the concrete surface. The sections and supports shall be removed and the holes filled with concrete immediately after the final straightedging. The finishing machine shall make sufficient passes to obtain the specified cross section and surface finish. The final pass of the machine shall be of maximum practicable length and shall be coordinated with the rate of placement. Finishing machine loads will not be permitted on concrete less than 48 hours old.

**703.3.14.2** Where hand finishing of riding surfaces is permitted, the surface shall be struck off to the design section by a rigid metal shod template. The template shall be supported on rails or guides that can be adjusted to produce the design section and slab thickness. The rails or guides shall be supported above or outside the concrete surface. The surface behind the template shall be finished with a longitudinal float. The longitudinal float shall have a rigid metal shod smoothing surface which is a true plane not less than 10 feet (3 m) long and 8 inches (200 mm) wide. The float shall be operated from movable bridges with a combined longitudinal and transverse motion. Each transverse pass shall overlap the previously floated area by approximately one-half the length of the float.

**703.3.14.3** Sufficient work bridges shall be provided to complete the work in an orderly and continuous manner. Work bridges shall be supported outside the limits of concrete placement.

**703.3.14.4 Straightedging.** The riding surface shall be checked with a 10-foot (3 m) straightedge immediately after the final finishing operation. The straightedge shall be pulled lightly across the surface from one edge of the finished area to the other without interruption. Reaching from outer edges to the center of the finished area will not be permitted. Each transverse pass shall overlap the previously straightedged portion by approximately one-half the length of the straightedge. The straightedge shall not be used to cut or move concrete from its finished position. Any irregularities, bumps or improperly finished areas shall be refinished and the surface again checked by repeating the straightedging operation.

**703.3.14.5 Roadway Finish Texture.** The roadway surface, except within 12 inches (300 mm) of the inside face of the curb, shall be textured as soon as the condition of the concrete will permit. The roadway finishing shall otherwise conform to the applicable portions of [Sec 502.10.3](#). Hand operated devices producing a satisfactory texture will be permitted. At the contractor's option a finned float with a single row of fins may be used. The grooves produced by the finned float shall be approximately 1/8 inch (3 mm) in width at 5/8 inch (16 mm) to 3/4 inch (19 mm) centers and be approximately 1/8 inch (3 mm) deep. This operation shall be performed at such time and in such a manner that the desired texture will be achieved while minimizing displacement of the layer aggregate particles.

**703.3.14.6 Surface Test.** As soon as curing has been completed, the riding surface will be thoroughly straightedged by the engineer and all variations exceeding 1/8 inch in 10 feet (3 mm in 3 m) will be plainly marked. Areas more than 1/8 inch (3 mm) high shall be removed by an approved device consisting of multiple cutting edges leaving a grooved surface finish comparable to that produced by the broom. The use of a bush hammer or other impact device will not be permitted.

**703.3.14.7** Unless an armored joint is shown on the plans, construction and expansion joints in the roadway surface shall be carefully edged and left free of all mortar and concrete. These



joints shall be sealed with joint sealing material if shown on the plans. Joints shall be dry and shall be cleaned immediately before they are sealed. Required joint sealing shall be done prior to surface sealing the bridge deck.

**703.3.15** Surface finish for concrete masonry units, other than those specified in [Sec 703.3.14](#), shall begin immediately following removal of the forms. Fins and irregular projections shall be removed. Form tie cavities, holes, honeycomb spots in other than exposed surfaces, and other defects, shall be thoroughly cleaned, saturated with water and carefully pointed with a mortar in accordance with [Sec 703.3.8](#). Repaired surfaces shall be satisfactorily cured.

**703.3.16** Bridge seats shall be finished with a wood float to a smooth even surface. Where lead plates or fabric pads are used to seat steel bearing plates, the area under the lead plates or fabric pads shall be finished to within 1/8 inch (3 mm) above plan elevation and shall be dressed to a uniform, level bearing with a Carborundum brick or power grinder after the concrete has set sufficiently to fix the larger particles of sand. The deviation of the bearing seat from a true level surface shall not exceed 1/16 inch (1.5 mm). Where elastomeric bearing pads are used, the finishing of 1/8 inch (3 mm) above plan elevation and grinding of the bridge seat area will not be required. Wells for anchor bolts shall be completely filled with an expansive type mortar meeting the requirements of [Sec 1066](#) after the steel has been erected and adjusted. In lieu of wells, anchor bolt holes may be drilled in accordance with [Sec 712.6](#). Keyways, anchor bolt wells and holes, and other depressions which might collect water and freeze shall be sealed.

**703.3.17 Curing.** Curing of exposed concrete masonry surfaces shall be in accordance with [Sec 502.12](#) except as follows: Riding surfaces and other surfaces to be surface sealed shall be cured with mats of jute, cotton or other suitable fibers. Curing mats shall be applied as soon as the concrete has set sufficiently that no marring of the surface or distortion will result. The mats at the time of placement shall be sufficiently wet to prevent moisture absorption from the finished surface. The mats for curing riding surfaces shall be kept continuously wet by use of a sprinkler, soaker hose or similar means until the concrete has attained at least the compressive strength shown in [Table I](#), but in no case for less than five days. The mats for curing other surfaces shall be kept continuously wet for 72 hours. The mats shall then remain in place until they are dry or, if not dry, for at least 24 hours after the end of the wet curing period. Surfaces to be dampproofed, and railroad bridge decks to be waterproofed, shall not be cured with membrane. Such surfaces may be cured by the use of the prime coat specified in [Sec 708.3.2](#). Other exposed surfaces shall be cured by covering with transparent membrane applied in accordance with the requirements of [Sec 502.12.1](#), or by the use of wet burlap. If permitted by the engineer, footings may be cured by submersion.

**703.3.17.1** Steam curing or curing by complete submersion in water will be permitted for precast members. If steam curing is applied, the jets shall not impinge directly on the concrete or on the forms; free circulation around the units shall be maintained; the steam shall be thoroughly saturated at all times; the temperature around the concrete shall not be raised more than 40 F (20 C) per hour and shall not exceed 160 F (70 C) at any time. After the expiration of the steam curing period, the temperature inside the chamber shall be reduced at a rate of not more than 40 F (20 C) per hour until a temperature has been reached about 20 F (10 C) above the temperature of the air to which the concrete will be exposed.

**703.3.17.2** Curing concrete for box girder superstructures shall begin as soon as possible after completion of each concrete placement. Wet mats shall be used for curing the top surface of the bottom slab and the exposed top surfaces of girders and diaphragms for at least 72 hours after the concrete has been placed. Immediately after the removal of the wet mats from these units, transparent or white pigmented membrane curing material shall be applied to all surfaces, except surfaces of construction joints, in accordance with [Sec 502.12.1](#) unless these

items have attained the applicable strength specified in [Table I](#). The interior surfaces of girders and diaphragms shall be cured by leaving the forms in place for 5 days or by applying membrane. The membrane curing shall be in accordance with the requirements of [Sec 502.12.1](#) except that the membrane shall be applied with a brush or roller.

**703.3.17.3** Structures shall not be opened to any construction or public vehicular traffic nor will heavy or concentrated loading by material be permitted until the concrete has reached a compressive strength of 3200 pounds per square inch (22 MPa).

**703.3.18 Scale Prevention Treatment.** Bridge decks, except those which are to be surfaced later, shall be treated with one application of an approved mixture of equal parts, by volume, of commercially available double-boiled linseed oil and mineral spirits. The material shall be applied to the top surface of roadways, and the top and roadway faces of concrete sidewalks, curbs, parapets and medians. It shall be applied on a clean, dry surface of concrete that has been allowed to dry a minimum of 48 hours after curing mats have been removed and before the bridge is opened to other than essential construction traffic. Foreign material on the surface shall be removed and the ambient temperature shall not be below 35 F (2 C) at the time of application. The application of the mixture shall be at the rate of not less than 0.05 gallon per square yard (0.25 L/m<sup>2</sup>). The mixture may be sprayed or flowed on, or applied with an approved distributor, and shall be thoroughly broomed, brushed or mopped on all specified surfaces.

**703.3.19 Hot Weather Concreting.** When the weather forecast predicts temperatures of 90 F (32 C), or higher, the contractor shall schedule placing and finishing of bridge deck concrete during hours in which the ambient temperature will be lower than 90 F (32 C). The mixed concrete when placed in the forms shall have a temperature no higher than 90 F (32 C). The forms and reinforcing steel shall be cooled by acceptable methods, such as covering with wet burlap for at least 12 hours prior to the placing of concrete. The concrete shall be protected with wet curing mats as soon as it has hardened sufficiently to allow their placement.

**703.3.20 Cold Weather Concreting.** Concreting shall proceed on all structures, except bridge superstructures, whether or not heating is required, unless it can be definitely established that the overall progress of the project will not be affected. Placing of concrete in the superstructure of a continuous or monolithic series of spans once begun shall be continued within the provisions of cold weather concreting procedures until all the concrete in that series is placed. Concrete placed in cold weather shall be protected from freezing during the curing period by the use of a heated weatherproof enclosure. Concrete shall not be placed on frozen ground, nor against steel or concrete surfaces with temperatures lower than 35 F (2 C). No concrete shall be placed where the ambient temperature is below 35 F (2 C), and concrete in bridge superstructures shall not be placed where the ambient temperature is below 45 F (7 C).

**703.3.20.1** The aggregates or water or both shall be heated during the season when the atmospheric temperature may drop below 40 F (5 C). Aggregates shall not be heated higher than 150 F (65 C). The temperature of the aggregates and water combined shall not be higher than 100 F (38 C) when the cement is added. Any method of heating during the mixing of concrete may be used, provided the heating apparatus will heat the mass uniformly and avoid hot spots which will burn the material. The temperature of the concrete at the time of placing in the forms shall not be lower than 45 F (5 C) for concrete in footings and massive piers and abutments, nor less than 60 F (16 C) for all other concrete.

**703.3.20.2** Curing of superstructure concrete, substructure units above ground surface, retaining walls and box culverts of more than 15 square feet (1.5 m<sup>2</sup>) opening shall be within a weatherproof enclosure when the ambient temperature is below 40 F (5 C). Temperature within the enclosure shall be uniformly maintained between 40 F (5 C) and 80 F (27 C) for not

less than seven days nor more than fourteen days. Heating may be discontinued after seven days provided the concrete has attained at least the applicable strength shown in [Table I](#). When dry heat is used, at least 40 percent relative humidity shall be maintained. The contractor shall provide adequate fire protection at all times and shall maintain proper temperature and humidity conditions within the housing during the curing period. The exposed surfaces of the concrete shall be kept moist either by the application of steam or wet burlap mats. When curing is complete, the temperature within the enclosure shall be lowered gradually at a rate not to exceed 3 F (2 C) per hour, until the outside temperature is reached. Substructure concrete below ground surface may be protected by submersion provided the temperature of the water is maintained between 40 F (5 C) and 80 F (27 C) for seven days.

**703.3.20.3** Insulated forms for cold weather protection may be used at approved locations in lieu of enclosures. The contractor shall secure written approval of the type of insulation, method of installation and the locations at which it is proposed for use.

**703.3.20.4** Concrete headwalls for pipe culverts, drop inlets and box culverts of 15 square feet (1.5 m<sup>2</sup>) or less opening, may be placed without air temperature limitations, but the contractor is not relieved of his responsibility for proper protection from freezing during placing and curing of the concrete.

**703.3.21** Extending and widening of existing concrete structures shall be in accordance with the details shown on the plans. A continuous groove at least one inch (25 mm) deep shall be sawed in the faces of the existing concrete as a guide for the line of break to prevent spalling. Surfaces of existing concrete which are to come in contact with new concrete shall be thoroughly cleaned, saturated with water and painted with a neat cement grout of painting consistency. The new concrete shall be placed immediately after the cement grout has been applied. If new concrete is to be placed against the natural finish of existing concrete work, the surface shall be roughened by bushhammering before being cleaned and treated. Before applying a new concrete riding surface, any existing bituminous surfacing shall be removed and the exposed concrete surface roughened by bushhammering before being cleaned and treated. No direct payment will be made for work incidental to joining new concrete to existing concrete.

**703.3.22** Bridge numbers shall be stenciled in black paint on all concrete bridges. The letters shall be capitals not less than 2 inches (50 mm) nor more than 3 inches (75 mm) high. The bridge numbers shall be stenciled on concrete surfaces at two locations as directed by the engineer.

#### **703.4 Method of Measurement.**

**703.4.1** Concrete masonry will be computed from the dimensions shown on the plans, or as revised in writing by the engineer, and will be computed to the nearest 1/10 cubic yard (0.1 m<sup>3</sup>) for each structure. No deduction will be made for the space occupied by reinforcing steel, conduit or piles. Deductions will be made for the space occupied by the tubes in voided slabs. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**703.4.2** Measurement of concrete quantities in seal courses will be made for the actual yardage (quantity) placed, except that this yardage (quantity) will be limited to that included within vertical planes 18 inches (450 mm) outside the neat lines of the footings proper, and to the maximum depth shown on the plans or as authorized by the engineer.

**703.4.3** Measurement of concrete quantities used to fill cavities or crevices will be made for the accepted yardage (quantity) placed below the authorized elevation of the structure footing.

**703.5 Basis of Payment.**

**703.5.1** The accepted quantity of concrete masonry, complete in place, will be paid for at the unit price for each of the pay items included in the contract.

**703.5.2** The accepted quantity of concrete used to fill cavities or crevices below final authorized bottom elevation of the footing structure will be paid for at a lump sum price of \$500.00 (\$650.00) if the accepted quantity is 2 cubic yards (2 m<sup>3</sup>) or less, or at the unit price of \$200.00 per cubic yard (\$250.00/m<sup>3</sup>) if the accepted quantity is more than 2 cubic yards (2 m<sup>3</sup>).

**703.5.3** No direct payment will be made for incidental items necessary to complete the work unless specifically provided as a pay item in the contract. No direct payment will be made for concrete required to fill overbreak where footings or walls are cast against vertical faces of rock or shale excavation.

## SECTION 704

### LIGHTWEIGHT (LOW MASS DENSITY) CONCRETE MASONRY CONSTRUCTION CLASS X CONCRETE

**704.1 Description.** This work shall consist of constructing structures of lightweight (low mass density) concrete, designated as Class X Concrete, composed of a mixture of cement, fine aggregate, lightweight (low mass density) fine and coarse aggregate, water and approved additives.

#### **704.2 Material.**

**704.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Fine Aggregate	<a href="#">1005.2</a>
Lightweight (Low Mass Density) Fine and Coarse Aggregate	<a href="#">1005.3</a>
Cement	<a href="#">1019</a>
Concrete Admixtures	<a href="#">1054</a>
Water	<a href="#">1070</a>

The lightweight (low mass density) concrete shall be proportioned, mixed and transported in accordance with the applicable provisions of [Sec 501](#). Each kind and size of aggregate shall be stored and proportioned separately.

**704.2.2 Mix Design.** The proportions of cement, fine aggregate and lightweight (low mass density) fine and coarse aggregates will be specified by the engineer within the limits of these specifications. Unless otherwise approved by the engineer, Grade 5 lightweight (low mass density) coarse aggregate shall be used. Twenty to 40 percent by volume of the fine aggregate shall be material naturally produced by the disintegration of rock of a siliceous nature and shall meet the requirements of [Sec 1005.2](#) with the gradation requirements of [Sec 1005.2.4.1](#). Class C or D sand, as defined in [Sec 501.2.2.3](#), shall not be used. The weight (mass) of freshly mixed Class X Concrete shall not be greater than 120 pounds nor less than 105 pounds per cubic foot (1920 nor less than 1680 kg/m<sup>3</sup>). The mixture shall have a slump, when placed, of not more than 2 inches (50 mm). If air-entrained concrete is specified, the entrained air content shall be 7 percent by volume, with an operating tolerance of plus or minus two percentage points.

**704.2.2.1** The cement content shall be 696 pounds per cubic yard (415 kg/m<sup>3</sup>), plus or minus 19 pounds (10 kg), as determined by using the batch weights (masses) and the weight per cubic foot (mass per cubic meter) of the fresh concrete in accordance with AASHTO T 121. High early strength cement may be used as provided for in [Sec 501.7](#).

**704.2.3 Concrete Admixtures.** Air-entraining admixtures, retarding admixtures, or water-reducing admixtures may be specified or may be permitted as set forth in [Sec 501](#). If used, these admixtures shall be proportioned, dispensed and mixed in accordance with [Sec 501](#).

**704.2.4 Trial Batches.** Prior to placement of any concrete in the work, the contractor may be required to prepare trial batches for tests. They shall be prepared sufficiently in advance of

placing concrete in the structure to permit determination of the seven day compressive strength of the concrete, or for such other tests as may be determined by the engineer. Generally, three trial batches, of not less than 2 cubic yards (1.5 m<sup>3</sup>) each, shall be mixed for testing. The batches shall be mixed in accordance with [Sec 704.3.2](#) and agitated in such manner to reproduce the time of haul and discharge time.

**704.3 Construction Requirements.** The following requirements shall be in effect except as may be modified by an approved alternate submitted by the contractor.

**704.3.1 Aggregates.** Storage of aggregates shall, in general, be in accordance with [Sec 501.5.3](#). A moisture sensing device in the fine aggregate bins or weighing hopper will not be required.

**704.3.1.1** All lightweight (low mass density) aggregates shall be stockpiled on the job or at a central batching plant for not less than 24 hours prior to use in the batches. Aggregates shall be stored in floored bins adjacent to the proportioning plant. The aggregates shall be pre-wetted and drained to a uniform moisture content meeting the approval of the engineer. Stockpiles shall be protected to prevent excessive evaporation of moisture after wetting. Wetting of stockpiles shall be done not less than 12 hours prior to use.

**704.3.2 Mixing.** While the mixer is in motion, it shall be charged with approximately one-half of the water and all the aggregate required for a batch. The aggregate and water shall be mixed at least one minute, after which the cement shall be added gradually. Additional water shall be added as required to produce the desired consistency. The mixing shall be continued for not less than five minutes after the entire batch is in the mixer. Some modification of the usual water measuring and dispensing equipment may be necessary to meet the requirements of these specifications. The consistency of the concrete mixture shall be kept uniform and the minimum quantity of water shall be used which will produce the desired workability. If central or truck mixed concrete is furnished, all batches shall be mixed ten additional revolutions at mixing speed immediately prior to discharge from the hauling unit. Central or truck mixed lightweight (low mass density) concrete shall be delivered to the site of the work and discharge completed within one hour after beginning of mixing operations.

**704.3.3 Placement.** Forming, placing, finishing and curing shall be in accordance with the applicable portions of [Sec 703](#). The concrete shall be placed by starting at one corner and along the header, vibrating the placed concrete uniformly and thoroughly, but not to such extent as to segregate the mixture. Additional concrete shall be placed on top of the leading edge of the concrete previously placed, and shall be adequately vibrated to consolidate the mixture under and around the reinforcing steel in such manner that the mixture will flow along the bottom of the form and come up around the reinforcing steel.

**704.4 Method of Measurement.** Class X Concrete will be computed from the dimensions shown on the plans, or as revised in writing by the engineer, and will be measured to the nearest 1/10 cubic yard (0.1 m<sup>3</sup>) for each structure. No deduction will be made for the space occupied by reinforcing steel or conduit. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

#### **704.5 Basis of Payment.**

**704.5.1** The accepted quantity of Class X Concrete will be paid for at the contract unit price. No direct payment will be made for surface sealing, furnishing and placing joint material,

water stops or flashing and other incidental construction attached to or incorporated in the concrete masonry.

**704.5.2** Payment for trial batches directed by the engineer in accordance with [Sec 704.2.4](#) will be made at 50 percent of the contract unit price for Class X Concrete.

## SECTION 705

### PRESTRESSED CONCRETE MEMBERS FOR BRIDGES

**705.1 Description.** This work shall consist of the fabrication and installation of prestressed concrete members, complete in place, in the superstructure of bridges. This work covers both pretensioned and post-tensioned members.

#### 705.2 Material.

**705.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete Structures	<a href="#">1036.1</a>
<b>Specification</b>	
Structural Steel	AASHTO M 183
Structural Steel (for anchorage plates)	AASHTO M 223, Grade 50
Steel Strand	AASHTO M 203
Wire and Parallel-Lay Wire Cables	AASHTO M 204
High-Tensile Strength Alloy Bars	AASHTO M 275

**705.2.2** Enclosures for post-tensioning tendons shall be mortar tight, semi-rigid metal tubes with an internal diameter at least 1/4 inch (6 mm) larger than the bar, cable, strand or wire group to be enclosed, and shall be provided with suitable entrance and discharge ports for grouting.

**705.2.3** Mortar for grouting tendons in post-tensioned members shall consist of a mixture of cement and fine sand in the approximate proportions of one part cement to 3/4 part sand, by volume, with sufficient water to form a grout having the consistency of heavy paint.

**705.2.4** Concrete material, proportioning, air-entraining, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#), except as noted in this section. Concrete for prestressed members shall conform to all requirements of Class A-1 concrete, except as noted in this section. The contractor may use Type I, IP, I(PM), IS, I(SM), Type II or Type III cement.

**705.2.5 Certification.** All wire, strand, bars and anchorage assemblies shipped to the site shall be assigned a lot number and tagged for identification. The contractor shall furnish three copies of the certified mill test report giving the chemical analysis and results of physical tests on the material furnished except chemical analysis will not be required for steel strand complying with AASHTO M 203. The contractor shall also furnish three certified copies of the stress-strain curve representative of the lot to be used.

#### 705.3 Equipment.

**705.3.1 Prestressing.** The contractor shall provide all equipment necessary for the construction and the prestressing of concrete members. Prestressing shall be done with approved jacking equipment. If hydraulic jacks are used, they shall be equipped with accurate pressure gauges. All gauges, load cells, dynamometers and other devices for measuring the stressing load shall have an accuracy within 2 percent. The combination of jack and gauge



shall be calibrated by a testing laboratory meeting the approval of the engineer. A certified graph or table showing the calibration shall be furnished the engineer. The total load as determined from the strand elongation shall check that indicated by the gauge within 5 percent of the total load required to achieve the designated elongation. If other types of jacks are used, proving rings or other devices calibrated by a testing laboratory meeting the approval of the engineer shall be furnished so that the jacking forces may be accurately determined. Calibration shall be repeated at intervals not exceeding one year and after each overhaul. While work is in progress, if any jack or gauge appears to be giving erratic results, or if gauge pressure and elongation indicate materially different stresses, recalibration may be required. The contractor shall furnish means of accurately measuring the elongation of the tendons to within 1/16 inch (1.5 mm). Elongation upon completion of stressing operations shall be within 5 percent of that specified. No tensioning of strands shall be done when strand temperatures are below 30 F (-1 C).

**705.3.2 End Anchorages.** End anchorages and stressing blocks for pretensioned members shall be adequately designed to withstand the forces incident to prestressing and to maintain the tension in all prestressed tendons of any member until the concrete has been placed and attained its specified transfer strength.

**705.3.3 Concrete Testing Equipment.** Equipment for field determination of compressive strength of concrete shall be furnished by the contractor at the location of manufacture of prestressed concrete members. The testing machine may be of any mechanical or hydraulic type, power operated in accordance with AASHTO T 22 Section 5.1.2.1, capable of testing cylinders to failure, and shall comply with the accuracy tolerances and corrections specified in AASHTO T 67, Section 16.1 and Section 17. Approximately the last one-half of the load shall be applied at a rate of between 1200 and 3000 pounds per square inch (8 and 21 MPa) per minute. The contractor shall furnish a sufficient number of 6 x 12-inch (152.4 x 304.8 mm) compression test cylinder molds of a type meeting the approval of the engineer. The contractor shall furnish sufficient personnel for cleaning and preparing reusable molds. The contractor shall, at the option of the engineer, furnish a technician(s) to assist the engineer with concrete testing and the making of test cylinders during the placing of concrete.

**705.3.4 Field Laboratory.** When requested, a Type 1 Field Laboratory, in accordance with [Sec 601](#), shall be furnished. No direct payment will be made for providing the laboratory.

#### **705.4 Construction Requirements.**

**705.4.1 Shop Drawings.** Shop drawings showing in detail the type, size, number of units, location of tendons, enclosures, method and sequence of releasing the strands, anchorage details and details of proposed lifting loops and lifting procedure shall be submitted to the engineer for approval. The method of prestressing will be optional with the contractor provided an approved specific method is used and the total prestressing force and the center of gravity of the prestressing tendons as shown on the plans are maintained. The shop drawings shall also tabulate the design computations and show the total prestress force, size and spacing of all reinforcing steel and concrete compressive strengths for strand release and design. No inspection will be conducted until the plant inspector has received a copy of the approved shop drawings. Prior to making shop drawings, the contractor shall submit in writing for approval of the engineer any proposed tack welding in lieu of tying of the reinforcing bars of prestressed members. If approved by the engineer, the location of tack welding of reinforcing bars shall be shown on the shop drawings submitted for approval. No heat or welding will be permitted in the proximity of prestressing tendons in the members.

**705.4.2 Forms and Formwork.** Forms and formwork, placing and tying of reinforcing bars, and placing and vibrating of concrete shall conform to the applicable requirements of [Sec 703](#) and [706](#), with the following additions:

(a) Clamps, bolts or other devices connecting the bulk-head to the side forms, inserts and blockouts shall be capable of being removed or loosened before steam curing is applied.

(b) The casting bed shall have a concrete deck on which the form grillage and soffit plates may be adequately centered, aligned and leveled to the same plane.

(c) Exterior forms for prestressed members shall be metal other than aluminum, mortar-tight and of adequate design to produce members within the tolerances specified.

(d) The temperature of the mixed concrete when placed shall not be higher than 90 F (32 C). The forms and reinforcing steel shall be cooled by acceptable methods to an ambient temperature of 90 F (32 C) or lower.

(e) Fabricating plants with demonstrated facilities for protection of the concrete during cold weather may, with the approval of the engineer, cast prestressed units when the ambient temperature is below 40 F (5 C). When the ambient temperature is below 40 F (5 C), the forms, or enclosures, and reinforcing steel shall be heated to attain and maintain a temperature of at least 40 F (5 C). No concrete shall be placed when the concrete temperature is below 60 F (15 C).

(f) The concrete for girders shall be placed in a minimum of two continuous lifts. Not more than 30 minutes shall elapse between the placing of contiguous lifts of concrete. The thickness of the first layer for I-girder beam sections shall be such that the top of the concrete is slightly above the top of the bottom fillet. The casting procedure shall be modified if the length of girders and placement conditions are such that an initial set of concrete may result if each lift is continued full length before another lift is placed.

**705.4.3 Prestressing Tendons.** Prestressing tendons for pretensioned members, and metal enclosures for post-tensioned members, shall be accurately placed and securely held during the placing and curing of the concrete. Strand chucks for pretensioning shall anchor the strand positively without slippage after seating. Strand chuck components shall be cleaned and inspected between each use and lubricated as necessary. All strands shall be free of contaminants such as dirt, oil, paint, wax, corrosion or other foreign material that may prevent bond between the strands and the concrete. The use of prestressing strands having kinks, bends, nicks or other defects will not be permitted. A light coating of rust will not be cause for rejection provided that the loose rust is removed and the surface of the strands is not visibly damaged. Tensioned strands shall be protected against excessive temperatures such as those produced by torches, welding equipment or sparks. Strands from more than one source shall not be used in any one tensioning operation.

**705.4.4 Strand Splices.** One approved splice per strand will be permitted provided the splices are located outside of the prestressed member. For single strand tensioning, the number of strands per bed that may be spliced is not restricted. If multi-strand jacking is used, either all strands shall be spliced or not more than 10 percent of the strands shall be spliced. Spliced strands shall be similar in physical properties, from the same source, and have the same twist or lay. Previously tensioned strands may be reused one time provided they meet all of the requirements of these specifications.

**705.4.5 Wire Failures.** Wire failures may be accepted provided not more than one wire in any strand is broken and the area of broken wires does not exceed 2 percent of the total area of the strands.

**705.4.6 Stressing Requirements.** The contractor shall provide a technician skilled in the use of the system of prestressing to supervise the prestressing operations.

**705.4.7 Elongation.** It is the responsibility of the contractor to compute the required elongation. Two copies of the computations shall be submitted to the engineer. The length of the strand to be used in calculating elongations shall be the actual length of the strand along its trajectory between the fixed anchorage and the reference point at jacking end of the strand. Stress losses due to slippage of strand anchorages, splice chucks and movement of anchorage abutments shall be included in the elongation computations.

**705.4.8 Pretensioned Members.** Prestressing tendons shall be uncoated seven-wire low relaxation strands conforming to AASHTO M 203, Grade 270. Several pretensioned members may be cast in one continuous line. The time intervening between the casting of the first and last member on a bed shall not exceed four days unless otherwise permitted by the engineer. When the temperature at the time of tensioning is such that correction must be made to compensate for change in strand stresses, all members on the bed shall be cast in a continuous pour. The tension in the strand as determined from the elongation at the time of placing concrete shall be within 5 percent of that specified. The stress to be given each strand shall be as shown on the plans. Pretensioning shall be by either the single strand or multi-strand jacking method. Each strand shall be brought to a uniform initial tension. The initial tension of each strand shall be accurately measured by a dynamometer or other approved means. The initial tension shall be within 50 pounds (200 N) or 2 percent of that required, whichever is the larger. The same jack used for single strand tensioning may be used for initial tensioning provided it is equipped with a proper gauging system for measuring the initial tension. Measurement of elongation shall not begin until initial tensioning has been completed. Strands tensioned as a group shall have the same initial tension, be from the same source, and have essentially the same modulus of elasticity. Coil ties shall be held in place in the forms by setting studs projecting through the forms. Studs shall be left in place until girders are erected and then replaced by coil tie rods. Alternate methods may be used, provided acceptable results are achieved. Coil ties shall have a concrete pull-out strength of not less than 9000 pounds in 3000 pounds per square inch (40 kN in 21 MPa) concrete.

**705.4.9 Post-Tensioned Members.** Post-tensioned members shall be stressed in such manner that the tension being applied and the elongation of the tendon may be measured at all times. The contractor shall furnish a certified record of gauge pressures and elongations to the engineer. Friction losses in the enclosures, elastic shortening and anchorage set shall be included in the computations for the required elongation of the tendon. In cases of discrepancies between gauge readings and the stress indicated by the elongation of the tendon, the elongation method of stress determination shall govern. Loads shall not be applied to the concrete until it has attained the design compressive strength shown on the plans. Tendons shall be stressed in a sequence to produce the least eccentricity of the load. Post-tensioning elements shall be placed in metal enclosures and after stressing shall be bonded by pressure grouting the space between the enclosure and the tendon. Enclosures shall be thoroughly cleaned of all foreign-material prior to grouting. The discharge ports shall be closed after all air has been forced out of the enclosure, as evidenced by the steady discharge of grout at its proper consistency, and a pump pressure of at least 50 pounds per square inch (345 kPa) maintained on the grout for a sufficient length of time to ensure completely filling all voids in the enclosure. Post-tensioned members shall not be removed from their supports for at least 24 hours after grouting.

**705.4.10 Strand Release.** Strands shall not be released until the concrete has attained the required compressive strength shown on the approved shop drawings. The compressive strength shall be determined by tests of standard cylinders made of concrete from the same batches and cured in the same manner as the members. The strands or prestressing elements shall be cut or released in a sequence that produces the least eccentricity of the load. If steam curing is used, strand release shall be performed while the members are still warm. Forms, hold down devices, or other appurtenances which may restrict movement of the members shall be removed or loosened prior to strand release. The sequence of release for hold down devices and strands shall be indicated on the shop drawings. Release shall be in accordance with the approved shop drawings.

**705.4.11 Curing.** Concrete members shall be kept continuously wet until the conclusion of the curing period. Curing shall be accomplished by covering with burlap or jute mats kept continuously wet by moist air, live steam or any combination of these methods. Other moist curing methods that will keep the member moist may be used provided the details of the proposed method are submitted to the engineer and approved. As soon as the concrete has set sufficiently that no marring of the surface or distortion will result, wet burlap or jute mats shall be applied, covering the exposed surface. Curing shall be continued until the concrete has attained the design compressive strength shown on the plans. The concrete shall not be exposed to temperatures below freezing until the curing has been completed.

**705.4.11.1 Steam Curing.** A preset period of not less than four hours shall be allowed before steam cure is applied. When the ambient temperature is below 50 F (10 C), steam shall be applied also during the preset period, but only at a rate sufficient to keep the air surrounding the member at a temperature between 50 F (10 C) and 70 F (20 C). After the preset period, steam shall be applied at a rate that will not increase the temperature of the air surrounding the members more than 40 F (20 C) per hour. The maximum curing temperature shall not exceed 160 F (70 C) and the difference in temperature adjacent to the concrete at different locations within the enclosure shall not exceed 30 F (15 C) at any time. Fluctuations of the temperature adjacent to the concrete during the curing period at any one location shall not vary more than 30 F (15 C). The contractor shall furnish and place, at the direction of the engineer a minimum of two portable recording thermometers, and not less than one for each 150 feet (45 m) of enclosure, for use in determining the magnitude and degree of uniformity of temperatures within the enclosure. The temperature recording system shall be capable of automatically producing a temperature record during the entire curing period. The temperature record shall show the temperature at each location at intervals of not more than 15 minutes and have a range of approximately zero to 200 F (-20 to 95 C). The temperature recording system shall be accurate within plus or minus 5 F (3 C). Steam shall be applied from pipes with perforations at suitable intervals laid along each side of the member, or by other approved arrangements. Jets of steam shall not be permitted to impinge directly against the member, forms or test specimens. Provisions shall be made for effective circulation of the steam around all portions of the members. The steam shall be thoroughly saturated at all times. If dehydration of the concrete or perceptible drying of the wet burlap initially placed on the concrete is noted, soaker hoses placed on top of the members, or other approved methods shall be used to supply sufficient moisture during the steam curing period. Steam curing shall continue until the required strength for transfer of load has developed. Steam or other curing methods shall continue until the concrete has attained the design compressive strength shown on the plans. After the expiration of the steam curing period, the temperature inside the chamber shall be reduced at a rate of not more than 40 F (20 C) per hour until a temperature has been reached approximately 40 F (20 C) above the temperature of the air to which the concrete will be exposed.

**705.4.12 Form Removal.** Forms shall not be stripped from prestressed concrete members sooner than 12 hours after casting. If strand release strength has then been attained, forms

may be removed and members moved without unnecessary delay, to a curing area. If forms are removed before the concrete has attained the strength which will permit the units to be moved or stressed, only the minimum area of the curing enclosure that is necessary to remove each individual form section shall be removed at any one time. The open area in the enclosure shall immediately be closed as each form section is removed. When the surrounding air temperature is below 30 F (-1 C), no portion of the enclosure shall be removed before the unit has attained the required transfer strength. Forms of test specimens shall be stripped at the same time the forms are removed from the members.

**705.4.13 Handling.** Handling and storage of prestressed members shall be performed with the members in an upright position and with points of support in approximately the same position as designated for the final position of the members in the structure. Members shall not be transported nor erected until the concrete has attained the design compressive strength shown on the plans. In storage, the members shall be fully supported across their width on battens that are not less than 4 inches (100 mm) wide. During transportation, the ends of I-beams shall not extend a distance of more than the depth of the beam beyond the bolsters or other supports on the transporting vehicle. Other beams shall not extend more than 1 1/2 times their depth beyond the supports on the transporting vehicle. During storage, the supports shall maintain the members in essentially a level position without twisting. Stacking of members in storage shall be done only with the approval of the engineer. If such permission is granted, the supports of all members shall be in the same vertical planes and shall be of adequate thickness to prevent damage to the lifting devices.

**705.4.14 Surface Finish, I-Girders.** Surface finish shall be in accordance with the requirements of [Sec 703.3.15](#), except that no cracks of any kind in post-tensioned members shall be filled before the stressing is completed. The engineer will determine the kind, type and extent of cracks and surface defects such as honeycomb and chipped edges or corners, that will be tolerated. Repairs may be permitted with mortar in accordance with [Sec 703.3.8](#). Commercially available patching material shall be used only if approved by the engineer. The top surface of members shall be scored transversely to a depth of approximately 1/4 inch (6 mm) with a wire brush, stiff broom or other approved method. A 3-inch (75 mm) wide strip at each end and at 1/4 points across the top flange of the member shall be smooth finished to accurate top flange depth. No laitance shall remain on surfaces to be embedded in concrete. After removal of hold-down devices, holes shall be plugged. If the method for plugging these holes is not shown on the shop drawings, written approval of the proposed method shall be obtained from the engineer. Exposed reinforcing steel shall be thoroughly cleaned of all concrete before delivery of members. The portions of girders to be embedded in the diaphragms at supports shall be roughened by sandblasting or other approved methods to provide suitable bond between girder and diaphragm. Mechanical benders, without the use of heat, shall be used to bend the strands on girders.

**705.4.15 Surface Finish, Tee Girders.** Surface finish shall be in accordance with the requirements of [Sec 703.3.15](#), except that no cracks of any kind in post-tensioned members shall be filled before the stressing is completed. The engineer will determine the kind, type and extent of cracks and surface defects such as honeycomb and chipped edges or corners, that will be tolerated. Repairs may be permitted with mortar in accordance with [Sec 703.3.8](#). Commercially available patching material may be used if approved by the engineer. The top surface of members shall be scored transversely to a depth of approximately 1/8 inch (3 mm). A 6 inch (150 mm) square area at each end and at 1/4 points of girders, centered on each stem, shall be smooth finished to accurate top flange depth. Laitance on surfaces to be embedded in concrete shall be removed by sandblasting, waterblasting or other approved methods. After removal of hold down devices, holes shall be plugged. If the method for plugging these holes is not shown on the shop drawings, written approval of the proposed method shall be obtained from the Division Engineer, Materials. Exposed reinforcing steel shall be thoroughly cleaned

of all concrete before delivery of members. The portion of girders to be embedded in the diaphragms at supports shall be roughened by sandblasting or other approved methods to provide suitable bond between girder and diaphragm. Mechanical benders, without the use of heat, shall be used to bend the strands on girders.

**705.4.16 Surface Finish, Deck Panels.** The top surface of the panel shall be scored to facilitate bond with the cast-in-place deck. The scoring shall be perpendicular to the prestressing strands in the panel and shall be approximately 1/8 inch (3 mm) in depth.

**705.5 Dimensional Tolerances.** The dimensional tolerances shall be as shown in Table I, II or III.

**705.6 Marking.** Each precast unit shall be identified with the date, manufacturer and identification number. Markings may be indented on the unit or painted thereon with waterproof paint, and shall be located as shown on the plans or as specified by the engineer.

**705.7 Erection.** Erection of the structure shall be in accordance with the working drawings. Camber of beams, measured as the differential between adjacent beams in their final location, shall be no more than 1/8 inch (1 mm) per 10 feet (1 m) of span, and in no case greater than 1 inch (25 mm).

**705.8 Method of Measurement.** Measurement will be made by individual units of each type and each length of prestressed members, complete in place, in the finished structure. The concrete, reinforcing bars, prestressing tendons, anchorages and accessories, enclosures, grout, coil ties and all other incidentals will be construed as comprising an individual unit.

**705.9 Basis of Payment.** Accepted prestressed concrete members will be paid for at the contract unit price.

<b>TABLE I</b> <b>DIMENSIONAL TOLERANCES - I-GIRDERS AND MISCELLANEOUS</b> <b>PRESTRESS UNITS</b>	
<b>ENGLISH</b>	
Length of Beam	±1/8 inch per 10 feet of beam length, but not greater than 3/4 inch
Width (Flanges, Web and Fillets)	+3/8 inch, -1/4 inch
Depth (Flanges, Web and Fillets)	±1/4 inch
Depth (Overall)	+1/2 inch, -1/4 inch
Horizontal Alignment (Deviation from a straight line parallel to centerline of member)	1/2 inch max., to 40-foot lengths 3/4 inch max., 40 to 60-foot lengths 1 inch max., 60-foot or greater lengths
Camber (Deviation from design camber within 7 days of strand release)	±1/2 inch, to 80-foot lengths ±1 inch, greater than 80-foot lengths
Stirrup Bars (Projection above top of beam)	±3/4 inch
Stirrup Bars (Longitudinal spacing)	±2 inches
Tendon Position	±1/4 inch center of gravity of strand group and individual tendons
Position of Deflection Points for Deflected Strands	±6 inches, longitudinal
Position of Lifting Devices	±6 inches, longitudinal
Side Inserts (Centerline to centerline and centerline to end)	±1/2 inch
Coil Inserts (Centerline to centerline and centerline to end)	±2 inches horizontal, except must be 3 inches or more from end of beam and within reinforcement cage of bent, ±1 inch vertical
Slab Drain Inserts	±1/2 inch from designated location, engineer may approve location ±6 inches from design, multiple inserts for single drain must be within ±1/2 inch of vertical line
Exposed Beam Ends (Deviation from square or designated skew)	±1/4 inch horizontal, ±1/8 inch vertical per foot of beam height
Bearing Area (Deviation from plane)	±1/8 inch
Bearing Plates (Centerline to centerline)	±1/8 inch per 10 feet of beam length, but not greater than 3/4 inch
Bearing Plates (Centerline to end of beam)	±1/2 inch
Diaphragm Hole Location	±1 1/2 inches for centerline of group ±1/2 inch within group

METRIC	
Length of Beam	±1 mm per meter of beam length, but not greater than 18 mm
Width (Flanges, Web and Fillets)	+9 mm, -6 mm
Depth (Flanges, Web and Fillets)	±6 mm
Depth (Overall)	+12 mm, -6 mm
Horizontal Alignment (Deviation from a straight line parallel to centerline of member)	12 mm max., to 12 m lengths 18 mm max., 12 to 18 m lengths 25 mm max., 18 m or greater lengths
Camber (Deviation from design camber within 7 days of strand release)	±12 mm, to 24 m lengths ±25 mm, greater than 24 m lengths
Stirrup Bars (Projection above top of beam)	±18 mm
Stirrup Bars (Longitudinal spacing)	±50 mm
Tendon Position	±6 mm center of gravity of strand group and individual tendons
Position of Deflection Points for Deflected Strands	±150 mm, longitudinal
Position of Lifting Devices	±150 mm, longitudinal
Side Inserts (Centerline to centerline and centerline to end)	±12 mm
Coil Inserts (Centerline to centerline and centerline to end)	±50 mm horizontal, except must be 75 mm or more from end of beam and within reinforcement cage of bent, ±25 mm vertical
Slab Drain Inserts	±12 mm from designated location, engineer may approve location ±150 mm from design, multiple inserts for single drain must be within ±12 mm of vertical line
Exposed Beam Ends (Deviation from square or designated skew)	±6 mm horizontal, ±10 mm vertical per foot of beam height
Bearing Area (Deviation from plane)	±3 mm
Bearing Plates (Centerline to centerline)	±1 mm per meter of beam length, but not greater than 18 mm
Bearing Plates (Centerline to end of beam)	±12 mm
Diaphragm Hole Location	±38 mm for centerline of group ±12 mm within group

Scupper holes, blockouts and voids shall be placed as close as possible to design location after reinforcement steel and strands are properly located.



<b>TABLE II</b> <b>DIMENSIONAL TOLERANCES – TEE GIRDERS</b> <b>ENGLISH</b>	
Length of Beam	±1/8 inch per 10 feet of beam length, but not greater than 1/2 inch
Width (Overall)	±1/4 inch
Depth (Overall)	±1/4 inch
Flange Thickness and Stem Thickness	±1/8 inch
Horizontal Alignment (Deviation from a straight line parallel to centerline of member)	1/4 inch max., to 40-foot lengths 3/8 inch max., 40 to 60-foot lengths 1/2 inch max., 60-foot or greater lengths
Camber (Deviation from design camber within 7 days of strand release)	±1/2 inch, to 80-foot lengths ±1 inch, greater than 80-foot lengths
Stirrup Bars (Projection above top of beam)	±3/4 inch
Stirrup Bars (Longitudinal spacing)	±2 inches
Tendon Position	±1/8 inch center of gravity of strand group and individual tendons
Strand Projection	±1 inch
Diagonal Tolerance	±1/4 inch
Position of Deflection Points for Deflected Strands	±6 inches, longitudinal
Position of Lifting Devices	±6 inches, longitudinal
Side Inserts (Centerline to centerline and centerline to end)	±1/2 inch
Coil Inserts (Centerline to centerline and centerline to end)	±2 inches horizontal, except must be 3 inches or more from end of beam and within reinforcement cage of bent, ±1 inch vertical
Exposed Beam Ends (Deviation from square or designated skew)	±1/4 inch horizontal, ±1/8 inch vertical per foot of beam height
Bearing Area (Deviation from plane)	±1/8 inch
Bearing Plates (Centerline to centerline)	±1/8 inch per 10 feet of beam length, but not greater than 3/4 inch
Bearing Plates (Centerline to end of beam)	±1/2 inch
Center of Stem to Outside Edge of Top Flange	±1/8 inch
Center to Center Distance Between Stems	±1/8 inch
Stem End to End of Top Flange	±1/4 inch
Diaphragm Hole Location	±1 1/2 inches for centerline of group ±1/2 inch within group

METRIC	
Length of Beam	±1 mm per meter of beam length, but not greater than 12 mm
Width (Overall)	±6 mm
Depth (Overall)	±6 mm
Flange Thickness and Stem Thickness	±3 mm
Horizontal Alignment (Deviation from a straight line parallel to centerline of member)	6 mm max., to 12 m lengths 9.5 mm max., 12 to 18 m lengths 12 mm max., 18 m or greater lengths
Camber (Deviation from design camber within 7 days of strand release)	±12 mm, to 24 m lengths ±25 mm, greater than 24 m lengths
Stirrup Bars (Projection above top of beam)	±18 mm
Stirrup Bars (Longitudinal spacing)	±50 mm
Tendon Position	±3 mm center of gravity of strand group and individual tendons
Strand Projection	±25 mm
Diagonal Tolerance	±6 mm
Position of Deflection Points for Deflected Strands	±150 mm, longitudinal
Position of Lifting Devices	±150 mm, longitudinal
Side Inserts (Centerline to centerline and centerline to end)	±12 mm
Coil Inserts (Centerline to centerline and centerline to end)	±50 mm horizontal, except must be 75 mm or more from end of beam and within reinforcement cage of bent, ±25 mm vertical
Exposed Beam Ends (Deviation from square or designated skew)	±6 mm horizontal, ±10 mm vertical per foot of beam height
Bearing Area (Deviation from plane)	±3 mm
Bearing Plates (Centerline to centerline)	±1 mm per meter of beam length, but not greater than 18 mm
Bearing Plates (Centerline to end of beam)	±12 mm
Center of Stem to Outside Edge of Top Flange	±3 mm
Center to Center Distance Between Stems	±3 mm
Stem End to End of Top Flange	±6 mm
Diaphragm Hole Location	±38 mm for centerline of group ±12 mm within group

Scupper holes, blockouts and voids shall be placed as close as possible to design location after reinforcement steel and strands are properly located.

<b>TABLE III</b>	
<b>DIMENSIONAL TOLERANCES – DECK PANELS</b>	
<b>ENGLISH</b>	
Length	+1/8 inch, -1/2 inch
Width	±1/4 inch
Depth	±1/8 inch
Stirrup Bars (Projection above top of panel)	±1/4 inch
Stirrup Bars (Longitudinal spacing)	±1 inch
Tendon Position	±1/8 inch center of gravity of strand group and individual tendons
Strand Projection	±1 inch
Diagonal Tolerance	±1/4 inch
<b>METRIC</b>	
Length	+3 mm, -12 mm
Width	±6 mm
Depth	±3 mm
Stirrup Bars (Projection above top of panel)	±6 mm
Stirrup Bars (Longitudinal spacing)	±25 mm
Tendon Position	±3 mm center of gravity of strand group and individual tendons
Strand Projection	±25 mm
Diagonal Tolerance	±6 mm

Maximum permissible warpage of one corner out of plane of the other three shall be 1/16 in./ft (5 mm/m) times the distance from the nearest adjacent corner.

Bowing or camber, concave or convex, of any part of a flat surface shall not exceed length of bow in inches (millimeters) divided by 360, with maximum of 3/4 inch (19 mm); and differential bowing or camber between the adjacent members of the same design shall not exceed 1/4 inch (6 mm).

The butt joints between precast panels shall be caulked to prevent excessive grout leakage between panels.

Scupper holes, blockouts and voids shall be placed as close as possible to design location after reinforcement steel and strands are properly located.

## SECTION 706

### REINFORCING STEEL FOR CONCRETE STRUCTURES

**706.1 Description.** This work shall consist of furnishing and placing reinforcing steel of the shape, size and grade required.

**706.2 Material.**

**706.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete	<a href="#">1036</a>

**706.2.2** Reinforcing steel shall be accurately cut and bent to the dimensions and shapes shown on the plans, preferably at the mill or shop. Cutting and bending tolerances for reinforcing steel shall be in accordance with the Concrete Reinforcing Steel Institute's manual of standard practice.

**706.3 Construction Requirements.**

**706.3.1** Reinforcing steel shall be protected from damage at all times. When placed in the work, it shall be free from dirt, oil, paint, grease, loose mill scale, thick rust and other foreign substances. Thin powdery rust need not be removed. All reinforcing steel required for superstructure concrete, such as slabs, girders and beams and top slabs of concrete box culverts of more than 4-foot (1.2 m) span, shall be held securely in correct position by means of approved metal or plastic bar supports and ties. These supports shall be manufactured and placed in accordance with the typical details shown on the plans for the various types of superstructures. Plastic bar supports shall meet or exceed the load carrying capacity of, and use the same spacing as, metal bar supports, and shall be molded in a configuration that does not restrict concrete flow and consolidation around and under the bar support. Reinforcing bars shall be positively secured against displacement. For bridge decks and top slabs of culverts, bars in the top mat shall be firmly tied with wire at each cross or lap. At other locations, the bars shall be firmly tied at the alternate crossings, or closer. The steel shall be tied in correct position and inspected before any concrete is placed. Such inspection will not relieve the contractor of the responsibility for constructing the unit in accordance with the plans. Care shall be exercised to maintain proper clearance between the forms and the reinforcement. Measurements to reinforcing steel shall be made to the centerline of bar, except where clear distance from face of concrete is shown on the plans. Before concrete is placed, any dried mortar shall be cleaned from the reinforcing steel.

**706.3.2** Bars shall not be spliced except where shown on the plans or permitted by the engineer. The use of splices shall be avoided at points of maximum stress. Where possible, splices shall be staggered and arranged to develop the full strength of the bar. Splices shall be made by lapping the bars a length at least equal to that shown on the plans or as authorized by the engineer.

**706.4 Method of Measurement.** Measurement will be made to the nearest 10 pounds (5 kg) for each structure. The weight (mass) paid for will be the theoretical weight (mass) of plain bars, and no allowance will be made for the clips, wire, supports and spacers or other fastening devices for holding the reinforcement in place. Allowance will not be made for an overrun in

scale weights (masses) of bars. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**706.5 Basis of Payment.** The accepted quantity of reinforcing steel, complete in place, will be paid for at the contract unit price.

## SECTION 707

### CONDUIT SYSTEM ON STRUCTURE

**707.1 Description.** This work shall consist of furnishing and placing all material and equipment and performing all work necessary to make a complete raceway as shown on the plans.

**707.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Electrical Conduit	1060

The type of conduit will be specified on the plans. Junction boxes used in the conduit system shall be cast iron with hot-dip galvanized finish inside and out.

#### **707.3 Construction Requirements.**

**707.3.1** Conduit bends shall be made in a neat and skillfull manner. No crushed or damaged conduit shall be used. Conduit ends shall be reamed to remove all burrs, and all cuttings resulting from reaming shall be removed from the conduit before installation. The ends of conduit runs shall be protected by bushings and shall be capped temporarily if conductor cable is not installed immediately. Conduit shall be rigidly held in place to prevent misalignment during placement of concrete. Care shall be exercised when placing concrete to prevent damage to the conduit. Concrete shall be thoroughly worked around the conduit so that there will be complete encasement without voids. Reinforcing bars shall not be cut, bent, displaced or otherwise altered unless authorized by the engineer. Joints in rigid steel conduit shall be made by means of threaded connections treated with good quality commercially available joint compound to make a waterproof joint. Expansion fittings for the conduit shall be as shown on the plans. A 1/2-inch (13 mm) diameter drain hole in all low points of conduits and junction boxes where exposed, and a 1/2-inch (13 mm) rigid steel conduit drop from the low point if the conduit and junction boxes are encased in concrete, shall be provided for drainage of water. Exposed ends of such drains shall be covered with 18 x 14 mesh copper insect screen wire held in place with a conduit bushing.

**707.3.2** Immediately after placing concrete, the conduit around which the concrete is placed shall be tested by the contractor, in the presence of the engineer, for continuity and freedom from obstruction by pulling a steel ball through the entire length. The steel ball shall have a diameter 1/2 inch (13 mm) smaller than the inside diameter of the conduit being tested. Galvanized pullwires shall be installed in conduits for pulling wiring by others.

**707.3.3** Junction box covers shall be waterproofed with cemented rubber gaskets and securely bolted in place. The junction boxes shall be drilled and tapped for all conduit connections.

**707.4 Method of Measurement.** The work provided herein will not be measured for payment, but will be considered a lump sum unit.

**707.5 Basis of Payment.** The accepted conduit system on structure will be paid for at the contract lump sum price.

## SECTION 708

### DAMPPROOFING

**708.1 Description.** This work shall consist of the application of dampproofing material below the ground line on those portions of substructure units or walls designated in the contract. Dampproofing will be classified as Ordinary Dampproofing or as Special Dampproofing.

#### 708.2 Material.

**708.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Dampproofing and Waterproofing Material	<a href="#">1072</a>

#### 708.3 Construction Requirements.

**708.3.1** Dampproofing shall not be applied in wet weather nor when the ambient temperature is below 50 F (10 C). Concrete shall be dry and clean before dampproofing is applied. If bituminous material is used for curing, it may also serve as a priming coat, except that additional primer may be necessary before application of the top coat. The bitumen for dampproof mop coat shall be carefully heated to a temperature within the following limits:

Asphalt	300 - 350 F (150 - 175 C)
Coal-Tar Pitch	200 - 250 F (90 - 120 C)

The bitumen shall be heated in kettles equipped with armored thermometers, and stirred frequently.

**708.3.2 Ordinary Dampproofing.** Ordinary dampproofing shall be applied by covering the surfaces either with (1) a light priming coat of asphaltic primer and an asphalt mop coat or (2) with a creosote priming coat and a coal-tar pitch mop coat. The application of primer shall be allowed to cure properly before applying the mop coat. The primer shall be applied without heating at the approximate rate of one gallon per 100 square feet (0.4 L/m<sup>2</sup>) of surface with a three or four knot roofing brush. If asphalt primer is too thick to allow easy brushing, the material may be thinned by the addition of a small quantity of gasoline or naphtha. After the primer has cured, the mop coat shall be applied at the rate of approximately 50 pounds per 100 square feet (2.5 kg/m<sup>2</sup>) of surface to obtain a thickness of approximately 5/64 inch (2.0 mm) for the dampproof coating.

**708.3.3 Special Dampproofing.** If special dampproofing at joints is specified, it shall consist of applying a coat of primer as specified in [Sec 708.3.2](#). After the primer has cured, a 50-pound (2.5 kg/m<sup>2</sup>) mop coat shall be applied as specified in [Sec 708.3.2](#). While this mop coat is still hot, there shall be applied a strip of bituminous treated cotton fabric which shall extend at least 6 inches (150 mm) each side of construction and expansion joints. A second mop coat shall then be applied at the rate of 30 pounds per 100 square feet (1.5 kg/m<sup>2</sup>) to obtain a thickness of approximately 3/64 inch (1.2 mm), and while still hot another strip of bituminous treated cotton fabric shall be applied, extending 3 inches (75 mm) beyond the edges of the first layer of fabric. The entire surface of the fabric shall be given a final 50-pound (2.5 kg/m) mop

coat. On surfaces that are vertical or nearly so, the strips of cotton fabric shall be placed vertical or with the slope. On other surfaces, the strips shall be laid shingle fashion, beginning at the lowest part of the area to be dampproofed. All fabric shall be pressed into place in the hot bitumen to eliminate air bubbles and to bring it into close contact with the concrete surface.

**708.3.4** Patching of defective dampproofing, where necessary, shall extend at least 12 inches (300 mm) beyond the outermost edge of the defective portion. The second ply of the patch shall extend at least 3 inches (75 mm) beyond the first ply.

**708.3.5** Work shall be so regulated that at the end of the day all fabric that has been applied will have received the final coat of bitumen.

**708.4 Basis of Payment.** No direct payment will be made for dampproofing.



## SECTION 709

### WATERPROOFING

**709.1 Description.** This work shall consist of furnishing and applying waterproofing material to concrete railroad bridge decks supporting ballasted track. Waterproofing shall consist of (1) one coat of asphaltic primer, (2) two layers of asphalt treated cotton fabric with three moppings of asphalt or if specified, three layers of asphalt treated cotton fabric and four moppings of asphalt, and (3) a protective covering of asphalt plank.

#### **709.2 Material.**

**709.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Joint Sealing Material	<a href="#">1057.1.4</a>
Dampproofing and Waterproofing Material	<a href="#">1072</a>

#### **709.3 Construction Requirements.**

**709.3.1** Waterproofing shall not be applied in wet weather, nor when the ambient temperature is below 50 F (10 C). Concrete shall be dry and clean before waterproofing is applied. If bituminous material is used for curing, it may also serve as a priming coat, except that additional primer may be necessary before application of the waterproofing material. Projections that might damage the waterproofing shall be removed. There shall be no depressions or pockets in horizontal surfaces of finished waterproofing except those required for drainage.

**709.3.2** Surfaces to be waterproofed shall, except as otherwise specified at joints, be primed in accordance with the requirements of [Sec 708.3.2](#). Joints shall be sealed with joint sealing material prior to application of waterproofing material. At deflection and expansion joints primer shall be omitted for a width of 18 inches (450 mm) on each side of the joint and a strip of impervious paper 36 inches (900 mm) wide shall be placed before waterproofing is applied.

**709.3.3** Surfaces to be waterproofed shall be mopped in sections. While the first mopping of asphalt is still hot, a strip of cotton fabric shall be laid on the mopping and pressed into place. Each mopping thereafter shall be so applied that it will completely cover and seal the cotton fabric. The asphalt for each application shall be applied at a rate of not less than 4 1/2 gallons per 100 square feet (1.8 L/m<sup>2</sup>) of surface. Asphalt shall be heated to permit uniform application but shall not be heated above a temperature of 350 F (175 C).

**709.3.4** Two layers of cotton fabric waterproofing shall be started by mopping a section of the surface 2 inches (50 mm) wider than half the width of the fabric. On this hot mopping, a half width of the fabric shall be laid. The top surface of this fabric and an adjacent section of the surface 2 inches (50 mm) wider than a half width of the fabric shall then be mopped. On this mopping shall be laid a full width of the fabric, completely covering the first strip. Thereafter full widths of fabric shall be laid in hot moppings, and in such manner that each strip will lap the second preceding strip by 2 inches (50 mm). End laps shall be not less than 12 inches (300 mm).

**709.3.5** Three layers of cotton fabric waterproofing shall be placed as for two layers, except that the first strip shall be a 1/3 width of the fabric; the second a 2/3 width; and the third and succeeding strips full widths. The second full strip shall lap the first strip at least 2 inches (50 mm). Each succeeding strip shall lap the third preceding strip at least 2 inches (50 mm).

**709.3.6** The waterproofing shall be turned into drainage openings without breaking. Waterproofing shall be made effective along the sides and ends of slab, at gussets, stiffeners and all other places where waterproofing terminates. Work shall be so regulated that at the end of the day all fabric that has been placed will have received a coat of asphalt. The waterproofing shall be free from punctures, pockets or folds. Patching of defective waterproofing shall extend at least 12 inches (300 mm) beyond the outermost edge of the defective portion. The second and each succeeding ply of the patch shall extend at least 3 inches (75 mm) beyond the preceding ply.

**709.3.7** Asphalt planking used as a protective covering shall be placed as soon as practicable after the waterproofing. The surface of the waterproofing shall be kept free of dirt or other foreign material. Immediately prior to laying the plank, a hot asphalt coating shall be applied at a rate of not less than 50 pounds per 100 square feet (2.5 kg/m<sup>2</sup>). The planks shall be laid tight against those previously placed, whose edges and ends shall have been heavily coated with hot asphalt. All joints shall be completely filled with hot asphalt.

**709.4 Method of Measurement.** Final measurement of waterproofing concrete railroad bridge decks will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity. The area will be computed to the nearest square yard (1.0 m<sup>2</sup>) for the actual surface area over which the waterproofing extends, including the portions of the faces of the curbs and ends of slab.

**709.5 Basis of Payment.** The accepted quantity of waterproofing of concrete railroad bridge decks will be paid for at the contract unit price.

## SECTION 710

### EPOXY COATED REINFORCING STEEL

**710.1 Description.** This work shall consist of furnishing and placing epoxy coated reinforcing steel of the shape, size and grade specified.

**710.2 Material.**

**710.2.1** All material shall conform to Division 1000 Materials Details, and specifically as follows:

Item	Section
Epoxy Coated Reinforcing Steel	<a href="#">1036.3</a>

**710.3 Construction Requirements.**

**710.3.1 Handling.** All systems for handling epoxy coated bars shall have padded contact areas. If, in the judgment of the engineer, the coating is damaged to the extent that the coating can no longer provide the intended protection, the material shall be returned to the coating applicator for repair or shall be replaced.

**710.3.2 Placement.**

**710.3.2.1** The epoxy coated bars shall be placed on plastic or plastic coated wire supports and shall be held in place by use of plastic coated tie wires or molded plastic clips. Plastic bar supports shall meet or exceed the load carrying capacity of, and use the same spacing as, metal bar supports, and shall be molded in a configuration that does not restrict concrete flow and consolidation around and under the bar support. When placing epoxy coated bars, they shall be prevented from coming into contact with other steel items such as drains and shear connectors.

**710.3.2.2** After the reinforcing bars are secured to approved bar supports a final visual inspection will be made and all uncoated or damaged areas shall be coated or repaired as required by the engineer.

**710.3.2.3** The contractor shall exercise caution when placing and vibrating concrete to prevent any damage to the epoxy coating. The vibrator head shall be equipped with a rubber tip and shall be a maximum diameter of 2 1/2 inches (65 mm). In order to prevent the vibrator from damaging the coated bars the head shall be covered with a sheet of rubber or a similar material as approved by the engineer.

**710.3.3 Repairing Bars.** If the epoxy coating is damaged, patching will be required. All damaged areas shall be patched with the material specified in [Sec 1036.3.5](#) and in accordance with the manufacturer's instructions. Patching will be required on all sheared or cut ends of bars, end areas left bare during the coating process, and any areas where the entire coating is removed. All repairs shall be completed as soon as practicable and in the case of bare end areas and sheared ends, before visible oxidation of the surface occurs.

**710.3.4 Method of Measurement.** Measurement will be made to the nearest 10 pounds (5 kg) for each structure. The weight (mass) paid for shall be the theoretical weight (mass) of plain bars, and no allowance will be made for the clips, wire, supports and spacers or other

fastening devices for holding the reinforcement in place. Allowance will not be made for an overrun in scale weights (masses) of bars. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**710.3.5 Basis of Payment.** The accepted quantity of epoxy coated reinforcing steel, complete in place, will be paid for at the contract unit price which shall include furnishing all material, cleaning, coating, equipment, tools, labor and any work incidental thereto. No separate payment will be made for patching material nor for any required repair of the coating.

## SECTION 712

### STRUCTURAL STEEL CONSTRUCTION

**712.1 Description.** This work shall consist of the fabrication, inspection, erection and painting of bridges and structures made of structural steel and miscellaneous metals.

**712.2 Material.**

**712.2.1** Except as amended by [Sec 712.2.3](#), all material shall conform to Division 1000, Material Details and specifically as follows:

Item	Section
Shear Connectors	<a href="#">1037</a>
Paint for Structural Steel	<a href="#">1045</a>
	<b>Specification</b>
Structural Steel	AASHTO M 270, Grade 36 (250) ASTM A 709, Grade 36 (250)
Structural Low Alloy Steel	AASHTO M 270, Grade 50 (345) ASTM A 709, Grade 50 (345) AASHTO M 270, Grade 50W (345W) ASTM A 709, Grade 50W (345 W)
Quenched and Tempered Alloy Steel	AASHTO M 270, Grade 70W (485W) ASTM A 709, Grade 70W (485W) ASTM A 709, Grade 100/100W (690/690W)
Low Carbon Steel Bolts and Nuts	ASTM A 307
High Strength Bolts, Nuts and Washers	AASHTO M 164 (ASTM A 325)
Cold Finished Carbon Steel Shafting	AASHTO M 169 (ASTM A 108)
Carbon Steel Forgings	AASHTO M 102 (ASTM A 668) Class F
Alloy Steel Forgings	AASHTO M 102 (ASTM A 668) Class G
Gray Iron Castings	AASHTO M 105 (ASTM A 48) Class 50
Malleable Iron Castings	ASTM A 47
Carbon Steel Castings	AASHTO M 103 (ASTM A 27) Grade 485-275
Galvanized Coatings	AASHTO M 111 (ASTM A 123)
Lead for Bearing Pads	ASTM B 29

**712.2.1.1** Bolts, nuts and washers specified to be galvanized shall be galvanized in accordance with the requirements of AASHTO M 232 (ASTM A 153), Class C or mechanically galvanized in accordance with the requirements of AASHTO M 298 (ASTM B 695), Class 55. Galvanizing thickness shall not exceed 6 mils (150 µm).

**712.2.1.2** Bolts, nuts and washers are not required to be galvanized when installed before completion of shop blast cleaning.

**712.2.1.3** Fit up and shipping bolts shall be coated to prevent corrosion where a finish coat will not be applied.

**712.2.2** Falsework material shall be subject to the engineer's approval. Timber material shall be sound, in good condition, and free from defects that will impair their strength. Steel members shall be in good condition and of a shape and strength suitable for the purpose intended. Falsework piling shall be capable of withstanding driving to a depth sufficient to develop adequate bearing.

**712.2.3** For structural steel, the contractor shall submit a copy of the certified mill test report giving the chemical analysis and results of physical tests on the material furnished. The mill test report shall also state the location of the mill where the molten metal was produced. Two copies of the mill test report will be required for material used in railroad structures. If the steel is produced outside the United States, the contractor shall submit a certified test report from a U. S. laboratory, approved by the State, showing specific results of chemical analysis and physical tests for each heat being furnished and stating that the material meets the specification requirements. Mill tests and laboratory reports shall be submitted for approval before any request is made for shop or field inspection. In addition, the State reserves the right to take samples for chemical analysis and physical tests from the fabricated steel delivered to the project site. Any delay caused by obtaining and analyzing samples from delivered steel shall not be cause for additional compensation nor extension of time for completion of the work.

**712.2.3.1** Unless otherwise specified, the supplementary requirements of AASHTO M 270 (ASTM A 709) for Charpy V-notch impact tests in temperature zone 2 shall be mandatory where the contract documents indicate notch toughness is required for fracture critical or non-fracture critical components. Mill test reports shall include the results of Charpy V-notch testing and the impact serial numbers for fracture critical components.

**712.2.4** For high strength bolts, nuts and washers; in addition to the requirements of [Sec 712.2.3](#), the contractor shall furnish a manufacturer's certification showing results of tests performed in accordance with the requirements of AASHTO M 164 (ASTM A 325) for bolts, AASHTO M 291 or M 292 (ASTM A 563 or A 194) for nuts and AASHTO M 293 (ASTM F 436) for washers. The testing of bolts and nuts shall include the proof load test. Identification shall be maintained by container markings which shall match identifying numbers on the certifications and be traceable to the certified mill test reports.

**712.2.5** For cast steel, the foundry shall furnish a certified copy of foundry reports giving the chemical analysis and results of physical tests on the material from each heat. These reports shall be submitted for approval of material being furnished before any required machine work is done on the castings.

**712.2.6** For gray iron castings, the foundry shall furnish one finished tension test specimen in accordance with AASHTO M 105 (ASTM A 48) from each heat. The required machine work shall not proceed until material being furnished has been approved. If cast steel is furnished in lieu of gray iron, the minimum tensile strength shall be 50,000 pounds per square inch (345 MPa).

**712.2.7** Machine finished surfaces shall be coated as soon as practicable, after being inspected and accepted and before being removed from the shop or placed in the open, with an application of one of the products qualified under Military Specifications MIL-C-11796 (Corrosion Preventive, Petrolatum, Hot Application). Other approved coatings may be used. In lieu of this coating, surfaces not in full contact may be given a shop coat of the primer specified for the paint system to be used.

**712.2.8 Identification of Metals.** The steel shall be stamped or stenciled and color striped with paint at the mill. Heat numbers shall be steel stamped or stenciled with paint at the mill. Separate markings and color codes shall be in accordance with AASHTO M 160 (ASTM A 6). The characteristic color stripes shall be placed on each part cut from the mill piece. For steels not covered by AASHTO M 160 (ASTM A 6), the fabricator shall furnish the engineer the color coding in writing before beginning fabrication. Heat numbers shall be painted on all principal pieces and these pieces shall be so noted on the shop drawings. Principal pieces for this requirement shall include all beams, flanges, webs, splice plates, cover plates, bearings, bearing stiffener plates, load bearing members of end diaphragms, pin plates, hanger plates and others as may be directed by the engineer. Principal pieces shall also include individual plates of all truss members, truss gusset plates, splice plates and floorbeam connection angles. The color code and heat number markings shall be placed on the material so as to be visible throughout the work of fabrication. Loss of identification on pieces or items will be cause for rejection of the pieces or items.

**712.2.8.1** Principal pieces requiring identification shall also include components of fracture critical members. Traceability of both heat numbers and impact serial numbers shall be maintained for fracture critical members and attachments.

**712.2.8.2** Unless otherwise indicated in the contract documents, steel plates for main members and splice plates for flanges and main tension members shall be cut and fabricated so the primary direction of rolling is parallel to the direction of the principal tensile or compressive stresses. The direction of rolling shall be maintained for all principal pieces during fabrication.

**712.2.9 Steel Stamping.** Any metal die stamping of match marks and erection marks in structural steel members shall be limited to a position in the end 1 1/2 inches (38 mm) of flange plates and flange splice plates, the middle third of web plates and the outside edge of the middle third of web splice plates. Metal die stamping at other locations or for other purposes may be approved by the engineer provided low stress dies are used. Low stress dies are those manufactured to produce impressions that are rounded at the bottom rather than sharp edged. The dies shall be lightly struck to produce the minimum impression that can be clearly seen in the absence of paint and mill scale. Metal die stamping on pin plates and hanger plates will not be permitted.

### **712.3 Fabrication and Inspection.**

**712.3.1 Quality Assurance Inspection.** The engineer will be responsible for QA inspection to assure the quality of the fabricated material. QA inspection by the engineer shall not relieve the contractor of the responsibility to provide fabricated structural steel items in accordance with the contract documents. Sufficient QC, as necessary to assure work being performed conforms to the contract documents, shall be considered the responsibility of the contractor and fabricator. Following adequate notification that QC inspections and testing by the fabricator have been performed, QA inspection will be at the option of the engineer. Regardless of the location and degree of QA inspection, material and workmanship not meeting specified performance criteria or conforming to the contract documents or recognized good practice may be rejected at any time prior to final acceptance of the work.

**712.3.1.1** QA inspection of fabricated material will ordinarily be made in the shop for fabricating shops within the 48 contiguous States and for shops outside the U. S. but within 1000 miles (1600 km) of Jefferson City. In some cases QA inspection in the fabrication shop may be waived and inspection made when the fabricated material is delivered to the project site. All costs of QA inspection at fabricating shops located both outside the 48 contiguous States and more than 1000 miles (1600 km) from Jefferson City, shall be borne by the

contractor. In such cases, the contractor will be charged with transportation costs and expenses of QA inspectors for trips made from Jefferson City to locations to which they must travel for shop inspection work. These transportation costs and expenses of QA inspectors will be deducted by the Commission from monies due the contractor.

**712.3.1.2** Regardless of where material is inspected, some QA inspection prior to actual fabrication will normally be required. If failures occur in the qualification of welders, welding procedures or welding processes that require additional inspection or additional witnessing, all costs and expenses incurred solely for the additional inspection or witnessing shall be borne by the contractor.

**712.3.1.3** The engineer shall be notified in advance of the beginning of the shop fabrication so a QA inspector may be present if so desired. Notification shall be made sufficiently in advance to allow the QA inspector to make travel arrangements. As a minimum, four working days notice shall be provided.

**712.3.1.4** The engineer shall have full access to all parts of the shop or project site where material is being fabricated or assembled, and shall be provided with every reasonable facility for determining the character of material and workmanship. All trusses, plate girders and continuous I-beams shall be assembled for inspection and be in a position that will permit the inspection of all parts. QA inspection of the assembly will be at the option of the engineer. If QA inspection of the fabricated material is performed at the project site, the contractor may be required to assemble the material for inspection prior to erection. The additional work of handling and assembly for QA inspection at the project site, any delay or additional costs caused by the inspection, required repairs or refabrication, securing samples for chemical analysis and physical tests, repair of areas where samples were removed or nondestructive testing of all repairs shall not be cause for additional compensation nor extension of time for completing the work.

**712.3.1.5** An enclosed office area for the exclusive use of the engineer, having not less than 120 square feet (11 m<sup>2</sup>) of floor space shall be provided at the location of QA inspection unless otherwise approved by the engineer. The area shall be weatherproof, secure, insulated and lighted. The area shall also be ventilated, heated and air conditioned with systems capable of maintaining an ambient air temperature of 72 F (22 C). Electric outlets with 110-120 volt, 60 Hz current and a telephone with outside line and inter-plant capabilities shall be provided. Office furniture consisting of a desk a minimum of 30 inches x 60 inches (750 mm x 1500 mm) with drawers, a swivel desk chair with arms and a storage/filing cabinet with lock hardware and key shall be provided. All office furniture shall be approved by the engineer. Should any furniture become unsatisfactory, it shall be promptly repaired or replaced to the satisfaction of the engineer. Parking shall be provided near the office with direct accessibility at any time the shop is in operation. No direct payment will be made for furnishing and maintaining an acceptable office area for QA inspection.

**712.3.1.6** All structural steel fabricators performing work for the following listed components of steel structures shall be certified prior to the start of fabrication under the appropriate category of the American Institute of Steel Construction (AISC) Quality Certification Program as follows:

(a) Fabricators of main load-carrying components of welded plate girders, box girders, trusses and arches shall be certified under the AISC Major Steel Bridges category (Cbr). Fabricators of fracture critical members shall be certified under this category with the additional endorsement for fracture critical capability.



(b) Fabricators of main load-carrying components for simple span or continuous rolled beam bridges and POT bearings shall, as a minimum, be certified under the AISC Simple Steel Bridge Structures category (Sbr).

(c) Fabricators of overhead sign trusses, temporary bridges and steel bearings shall, as a minimum, be certified under the AISC Conventional Steel Buildings category (Sbd).

(d) AISC certification will not be required for manufacturers of simple laminated or elastomeric bearing assemblies.

**712.3.2 Shop Drawings.** Shop drawings for structural steel and miscellaneous metals will be required, and shall be prepared in strict accordance with the design details shown on the plans. If details are lacking, they shall be supplied and shall conform to the design plans and specifications. All drawings shall be clear and complete, and shall be thoroughly checked before submittal. Four sets of prints of the shop drawings for railroad structures, and two sets for other structures shall be submitted for approval. The prints submitted shall be legible and have distinct details of sufficient contrast to be suitable for microfilming. Prints which do not have the desired clarity and contrast will be returned for corrective action. One set of these prints will be returned marked reviewed or approved subject to the corrections noted. The contractor shall promptly make the necessary corrections and resubmit for final approval. When shop drawings are finally approved, the contractor shall furnish as many additional prints as may be requested. Reproductions on cloth or film of the original shop drawings will be required for railroad structures and shall be delivered to the engineer prior to completion of the work. The approval of shop drawings will cover only the general design features, and in no case shall this approval be considered to cover errors or omissions in shop details. The contractor shall be responsible for the accuracy of the shop drawings, the fabrication of material and the fit of all connections. The contractor shall also bear the cost of all changes in the work in erection caused by errors in shop drawings and for any changes in fabrication necessary for satisfactory erection. After shop drawings have been approved, no changes in dimensions or substitutions of sections shall be made without written approval. Shop drawings shall be revised to show any authorized changes and the required number of prints shall be furnished the engineer.

**712.3.2.1** Shop drawings for fabricators located outside the 48 contiguous States, whether marked approved or approved subject to the corrections noted, will be returned to the contractor, and it shall be his responsibility to transmit them to the fabricator for further handling. Should such fabricator also be the contractor, all prints will be returned to the office located on the project.

**712.3.2.2** Shop drawings shall be completely titled in accordance with the contract plans and shall pertain to only a single structure.

**712.3.2.3** All welding procedures to be used shall be prepared by the manufacturer, contractor or fabricator as a written procedure specification and two copies shall be submitted prior to submitting shop drawings. The shop drawings submitted for approval shall indicate the welding procedure to be used for each joint.

**712.3.2.4** By submission of shop drawings, the contractor represents to the Commission that all materials, field measurements, construction requirements, performance criteria and similar data have been verified. By submission, the contractor further represents that the shop drawings have been coordinated and verified with the details of the work to be performed by other fabricators and entities on the project. No allowance for additional costs or delays will be made to the contractor for incorrect fabrication as a result of failure to coordinate or perform these verifications.

**712.3.3 Fabrication.** Fabrication of all parts of the structure shall be carefully done in strict accordance with the approved shop drawings.

**712.3.3.1** Straightening of any deformed structural material shall be performed by non-injurious methods prior to being laid off, punched or otherwise worked in the shop. Sharp kinks and bends will be cause for rejection.

**712.3.3.2** Holes for connections of main members shall be subpunched or subdrilled, and reamed while assembled in the shop or may be drilled from the solid with main members, and each splice plate fully assembled in their final erected positions. Holes for floor beams and framed stringer connections shall be drilled or reamed to a steel template of sufficient thickness to center the drill accurately, and all members to be secured through the same group of holes shall be drilled or reamed from the same template. Holes may be punched full size in secondary members such as lateral, longitudinal and sway bracing, lacing bars, stay plates and diaphragms.

**712.3.3.3** Subpunched holes for bolts having diameters greater than 3/4 inch (19 mm) shall be punched 3/16 inch (5 mm) smaller than the nominal diameter of the bolt. For bolts having a diameter of 3/4 inch (19 mm), the holes shall be punched 11/16 inch (18 mm) in diameter. For bolts having diameters of 5/8 inch (16 mm) or less, the holes shall be punched full size and spear reamed. The punch and die shall have the same relative sizes as specified in [Sec 712.3.3.6](#) for full size punched holes. After assembling, subpunched or subdrilled holes shall be reamed with tapered reamers to a diameter not more than 1/16 inch (1.5 mm) larger than the nominal diameter of the bolt.

**712.3.3.4** Holes drilled full size from the solid shall be 1/16 inch (1.5 mm) larger than the nominal diameter of the bolt.

**712.3.3.5** Reaming or drilling full size from the solid shall be done while the truss, girder, continuous I-beam or other component as noted, is assembled, either in an upright position or on its side, properly adjusted for camber and sweep and after the connecting parts have been firmly fastened together. A minimum of one full span, from bearing to bearing, shall be fully assembled before reaming or drilling full size shall begin. Connecting parts assembled in the shop for the purpose of reaming or drilling holes for field or shop connections shall not be interchanged or reversed and shall be matchmarked. A diagram showing such marks shall be detailed on the shop drawings. Burrs resulting from reaming, drilling or punching shall be removed. All connections shall be disassembled after drilling or reaming to make these holes accessible for deburring. Required cleaning and painting shall be done after this disassembly. Reamed, drilled or punched holes shall be round and perpendicular to the member. Any hole out of round more than 1/16 inch (1.5 mm) shall be cause for rejection of the plate. Eighty-five percent of the holes in any group shall not show an offset greater than 1/32 inch (1 mm) between adjacent thicknesses of metal after reaming or drilling. All of the holes shall be drilled or reamed and aligned so that a bolt of the specified diameter will enter the hole, and the head and nut will seat on the metal before tensioning.

**712.3.3.6** Punching full size holes for bolts in carbon steel may be done if the thickness of the metal does not exceed the specified diameter of the bolt. For carbon steel thicker than the specified diameter of the bolt, the holes shall be subpunched and reamed or drilled from the solid. Punching full size holes in alloy and low alloy steels may be done in material 5/8 inch (16 mm) thick or less. Holes in alloy or low alloy steel over 5/8 inch (16 mm) thick shall be subpunched and reamed or drilled from the solid. Except for special cases, the diameter of the punch for full size holes shall be not more than 1/16 inch (1.5 mm) greater than the diameter of the bolt, and the diameter of the die shall not be more than 1/16 inch (1.5 mm) greater than

the diameter of the punch. Punching shall be done accurately and there shall be no drifting to enlarge unmatched holes.

**712.3.3.7** All welding, oxygen cutting, shearing and clipping and dimensional tolerances shall be in accordance with requirements set forth in the ANSI/AASHTO/AWS D1.5-95, Bridge Welding Code. Tubular steel structures shall be governed by the current edition of the AWS D1.1, Structural Welding Code - Steel, in effect at the time of the contract, unless otherwise indicated. Aluminum structures shall be governed by the current edition of the AWS D1.2, Structural Welding Code - Aluminum, except as amended by [Sec 903](#), unless otherwise indicated.

**712.3.3.7.1** The following modifications to the ANSI/AASHTO/AWS D1.5-95, Bridge Welding Code (AWS), shall apply:

**712.3.3.7.1.1 AWS Sec 1.3 Paragraph 1.3.2** - Paragraph 1.3.2 shall be replaced with the following:

No electroslog or electrogas welding shall be used.

**712.3.3.7.1.2 AWS Sec 1.3 Paragraph 1.3.4** - Paragraph 1.3.4 shall be replaced with the following:

The gas metal arc welding process shall not be used on any structural components of bridges. Approved gas metal arc processes may be used for incidental, non-structural components as may be specifically approved by the engineer. Tack welding with an approved gas metal arc process is permissible for joints that will subsequently be welded using an approved submerged arc automatic welding process.

**712.3.3.7.1.3 AWS Sec 1.3 Paragraph 1.3.7** - A new Paragraph 1.3.7 shall be added as follows:

All primary shop welds shall be made by approved submerged arc automatic welding processes. The automatic welding process shall be one in which the wire or electrode feed, speed of travel and guidance are all mechanically controlled. Noncompliance with this requirement will be cause for rejection of the welded material unless prior approval is granted by the engineer for welding the specified joints by the use of other processes. The automatic welding process requirement for primary shop welds shall be shown on the shop drawings for each joint. Primary shop welds are defined as flange and web butt welded splices in I-beams, box members and plate girders, plate girder or box flange to web fillet welds and cover plate to flange fillet welds.

**712.3.3.7.1.4 AWS Sec 2.7 Paragraph 2.7.1.1** - Paragraph 2.7.1.1 shall be replaced with the following:

The minimum fillet weld size, except for fillet welds used to reinforce groove welds, shall be as shown in the following table or as calculated using procedures established to prevent cracking in accordance with Paragraph 4.2.2. In both cases, the minimum size applies if it is sufficient to satisfy design requirements.

<b>Material Thickness of Thicker Part Joined, in. (mm)</b>	<b>Minimum Size of Fillet Weld* in. (mm)</b>
To 1/2 (13) inclusive	3/16 (5)**
Over 1/2 (13) to 3/4 (19)	1/4 (6)**
Over 3/4 (19) to 1 1/2 (38)	5/16 (8)**
Over 1 1/2 (38) to 2 1/4 (57)	3/8 (10)
Over 2 1/4 (57) to 6 (150)	1/2 (14)
Over 6 (150)	5/8 (16)

\*Except that the weld size need not exceed the thickness of the thinner part joined.

\*\*Single pass welds must be used.

**712.3.3.7.1.5 AWS Sec 3.2 Paragraph 3.2.2.2 (4)** - A new Paragraph 3.2.2.2 (4) shall be added as follows:

Quenched and tempered steel plate may be thermally cut using good shop practices and provided sufficient preheating is applied according to the steel producer's written recommendations. Procedures for thermal cutting of quenched and tempered steel plate, along with the steel producer's written report, shall be submitted to the Bridge Division for approval prior to the start of such work.

**712.3.3.7.1.6 AWS Sec 3.2 Paragraph 3.2.3.4** - Paragraph 3.2.3.4 shall be replaced with the following:

The corrective procedures described in Table 3.1 shall not apply to discontinuities in rolled base-metal surfaces. Such discontinuities may be corrected by the fabricator in accordance with the provisions of ASTM A 6 (AASHTO M 160) except that repair by welding will be permitted only when approved by the engineer. Approval will be limited to areas where there will be less than the maximum design stress in the finished structure. When surface imperfections in alloy, low alloy and carbon steel plates are repaired by grinding, they shall have edges faired to the plate surface with a slope not exceeding 1 in 10.

**712.3.3.7.1.7 AWS Sec 3.4 Paragraph 3.4.6** - Paragraph 3.4.6 shall be replaced with the following:

All shop splices in each component part of a cover-plated beam or built-up member shall be made and all required nondestructive testing completed and approved by the engineer before the component part is welded to other component parts of the member. Long members or member sections may be made by shop-splicing subsections, each made in accordance with this subsection (see 9.17). All shop splices shall be made using full penetration welds that fully develop the capacity of the original member. Additional shop splices required due to length limits of available material may be used if they are detailed on the shop drawings and are placed at locations approved by the engineer. No additional payment will be made for any additional shop splices placed in the members at the option of the contractor, including shop splices that may be required as a result of material limitations.

**712.3.3.7.1.8 AWS Sec 3.5 Paragraph 3.5.1.3 and Table 3.2** - Paragraph 3.5.1.3 shall be replaced with the following, Table 3.2 shall be deleted and Table 3.3 shall remain in effect:

For welded beams or girders, except when the top flange is embedded in concrete without a designed concrete haunch, regardless of cross section, the allowable variation from required camber at shop assembly (for drilling holes for field splices or preparing field welded splices) shall be as follows:

at midspan

-0, +3/4 inch (+19 mm) for all spans

at supports

0 for end supports,  $\pm 1/8$  inch ( $\pm 3$  mm) for interior supports

at intermediate points

$$-0, + \frac{4(a)b(1-a/S)}{S}$$

where:

a = distance in feet (meters) from inspection point to nearest support

S = span length in feet (meters)

b = 3/4 inch (19 mm)

See Table 3.3 for tabulated values.

For members with the top flange embedded in concrete and no designed concrete haunch, the allowable variation from required camber at shop assembly (for drilling holes for field splices or preparing field welded splices) shall be as follows:

at midspan

-0, +3/4 inch (+19 mm) for spans  $\geq 100$  feet (30 m)

-0, +3/8 inch (+9.5 mm) for spans  $< 100$  feet (30 m)

at supports

0 for end supports,  $\pm 1/8$  inch ( $\pm 3$  mm) for interior supports

at intermediate points

$$-0, + \frac{4(a)b(1-a/S)}{S}$$

where:

a = distance in feet (meters) from inspection point to nearest support

S = span length in feet (meters)

b = 3/4 inch (19 mm) for spans  $\geq 100$  feet (30 m)

b = 3/8 inch (9.5 mm) for spans  $< 100$  feet (30 m)

See Table 3.3 for tabulated values.

Regardless of how the camber is shown on the detail drawings, the sign convention for the allowable variation shall be plus (+) above, and minus (-) below, the detailed camber shape.

These specifications also apply to an individual member when no field splices or shop assembly is required.

Camber measurements shall be made in the no-load condition.

**712.3.3.7.1.9 AWS Sec 3.5 Paragraph 3.5.1.8.1** - A new Paragraph 3.5.1.8.1 shall be added as follows:

The maximum permissible variation from specified width for rolled or burned flange plates shall be -1/8 inch to +3/8 inch (-3 mm to +9.5 mm).

**712.3.3.7.1.10 AWS Sec 3.5 Paragraph 3.5.1.9** - Paragraph 3.5.1.9 shall be replaced with the following:

The bearing ends of bearing stiffeners shall be flush and square with the web and shall have at least 75 percent of this area in contact with the inner surface of the flanges. The remaining 25 percent of the area of the bearing stiffener shall be within 0.010 inch (0.25 mm) of the inner surface of the flanges. When bearing against a steel base or seat, all steel components shall fit within 0.010 inch (0.25 mm) for 75 percent of the projected area of web and stiffeners and not more than 1/32 inch (0.8 mm) for the remaining 25 percent of the projected area. Girders without stiffeners shall bear on the projected area of the web on the outer flange surface within 0.010 inch (0.25 mm). The included angle between web and flange shall not exceed 90 degrees in the bearing length. The top surface of a flange or shelf plate supporting a steel bearing rocker shall be considered a flat surface with a tolerance of 0.003 inch per inch (0.003 mm/mm) in any direction over the projected area of the rocker. The top surface of a flange or shelf plate in direct contact with elastomeric bearings shall not deviate from a true plane surface by more than 1/16 inch (1.5 mm).

**712.3.3.7.1.11 AWS Sec 3.5 Paragraph 3.5.1.16** - A new Paragraph 3.5.1.16 shall be added as follows:

Permissible variation in length of assembled beams or girders between the centerline of bearing devices shall not exceed plus or minus 1/4 inch (6 mm) for any one span or plus or minus 3/8 inch (9.5 mm) for any two or more spans within the assembled unit. The actual centerline of any bearing device shall lie within the thickness of the bearing stiffener.

**712.3.3.7.1.12 AWS Sec 3.7 Paragraph 3.7.2.5** - A new Paragraph 3.7.2.5 shall be added as follows:

If, after two repairs to the same area of a weld requiring radiographic quality, there is any part of the original defect remaining or there is a new rejectable indication, the total joint shall be cut apart, all deposited weld metal removed, joint preparation made and the total joint rewelded. For welded joints requiring less than 100 percent radiographic quality, a third weld repair to an area may be made only with the approval of the engineer.

**712.3.3.7.1.13 AWS Sec 3.7 Paragraph 3.7.2.6** - A new Paragraph 3.7.2.6 shall be added as follows:

The gas metal arc welding process shall not be used for the repair of welds except when repairing welds made with the GMAW process.

**712.3.3.7.1.14 AWS Sec 5.21 Paragraph 5.21.6.2** - A new Paragraph 5.21.6.2 shall be added as follows:

Any cost involved in qualifying welders, welding operators and tackers, including all costs of material, finishing of test specimens, the physical testing of finished specimens and any radiography required, shall be borne by the contractor. Required radiography and physical testing of finished specimens shall be performed at test facilities approved by the engineer.

**712.3.3.7.1.15 AWS Sec 6.6 Paragraph 6.6.5** - Paragraph 6.6.5 shall be replaced with the following:

If nondestructive testing, not specified in the original contract agreement, is subsequently requested by the engineer, the contractor shall perform any requested testing or shall permit any requested testing to be performed. Handling, surface preparation, repair welds and any nondestructive testing requested by the engineer, as a result of weld repair, shall be at the expense of the contractor.

**712.3.3.7.1.16 AWS Sec 6.7 Paragraphs 6.7.1, 6.7.1.1 and 6.7.1.2** - Paragraphs 6.7.1, 6.7.1.1 and 6.7.1.2 shall be replaced with the following:

Radiographic inspection will be required for areas of both shop and field butt welds as specified herein. One hundred percent inspection will be required for flanges of rolled beams and girders and 100 percent of transverse butt welds in webs for a distance of not less than 1/6 of the web depth from each flange and 25 percent of the remainder of the web depth. At least 1/3 of the length of all longitudinal web splices shall be radiographed at even intervals throughout the length of the splice. When a rejectable defect is found by radiography in any partially tested joint, either initially or in a later additional radiograph, tests shall be made adjacent to and on either side of the rejectable test area. If a rejectable defect is found in any of these additional areas, then 100 percent of vertical web splices and an additional 10 percent of total weld length in longitudinal web splices shall be tested. The location of these additional test areas shall be as directed by the engineer.

**712.3.3.7.1.17 AWS Sec 6.10 Paragraph 6.10.3.4** - A new Paragraph 6.10.3.4 shall be added as follows:

Edge blocks shall be used when radiographing butt welds greater than 1/2 inch (13 mm) in thickness. The edge blocks shall have a length sufficient to extend beyond each side of the weld centerline for a minimum distance of 2 inches (50 mm) and shall have a thickness equal to the thickness of the weld, plus or minus 1/16 inch (1.5 mm). The minimum width of the edge blocks shall be not less than 1 inch (25 mm). The edge blocks shall be centered on the weld with a snug fit against the plate being radiographed, allowing no more than 1/16 inch (1.5 mm) gap. Edge blocks shall be made of radiographically clean steel and the surface shall have a finish of ANSI 125 or smoother (refer to ANSI/AWS D1.1-98 Structural Welding Code - Steel, Sec 6.17, Paragraph 6.17.13 and Figure 6.15).

**712.3.3.7.1.18 AWS Sec 6.10 Paragraph 6.10.11.2** - Paragraph 6.10.11.2 shall be replaced with the following:

If the greatest and least thickness of a weld connecting parts of different thickness cannot be rendered with adequate contrast on a single film with a single exposure, a dual film, or dual exposure technique shall be used to obtain suitable density for both the greatest and the least thickness of the weld.

**712.3.3.7.1.19 AWS Sec 6.12 Paragraph 6.12.4** - A new Paragraph 6.12.4 shall be added as follows:

After completion of all radiographic inspection, the contractor shall submit to the engineer one set of shop drawing details showing the location and identification numbers of all radiographs taken.

**712.3.3.7.1.20 AWS Sec 9.18 Paragraph 9.18.3** - A new paragraph 9.18.3 shall be added as follows:

Sheared edges of plates not to be welded that are more than 5/8 inch (16 mm) thick and carrying calculated stress shall be planed to a depth of 1/4 inch (6 mm).

**712.3.3.7.1.21 AWS Sec 9.20** - Sec 9.20 shall be replaced with the following:

Temporary welds shall be subject to the same WPS requirements as final welds. They shall be removed unless otherwise permitted by the engineer. When they are removed, the surface shall be made flush with the original surface. Unless previously approved in writing by the engineer, there shall be no temporary welds for fabrication, transportation, erection or other purposes on main members except at locations more than 1/6 the depth of the web from the flanges of beams and girders. There shall be no temporary welds in tension zones of members of quenched and tempered steels. Temporary welds at other locations shall be shown on shop drawings and shall be made with approved consumables. Removal of temporary welds shall conform to the requirements of Paragraphs 3.3.7.3 and 3.3.7.4.

**712.3.3.7.1.22 AWS Sec 9.21 Paragraph 9.21.2.1** - Paragraph 9.21.2.1 shall be replaced with the following:

For any welds, the greatest dimension of any porosity or fusion type discontinuity that is 1/16 inch (1.5 mm) or larger in greatest dimension shall not exceed the size, B, indicated in Figure 9.4 for the effective throat or weld size involved. The distance from any porosity or fusion type discontinuity described above to another such discontinuity, to an edge or to the toe or root of any intersecting flange-to-web weld shall not be less than the minimum clearance allowed, C, indicated in Figure 9.4 for the size of discontinuity under examination.

**712.3.3.7.1.23 AWS Sec 9.21 Paragraph 9.21.2.2 and Figure 9.5** - Delete paragraph 9.21.2.2 and Figure 9.5.

**712.3.3.7.1.24 AWS Sec 9.21 Paragraph 9.21.3.1** - Paragraph 9.21.3.1 shall be replaced with the following:

Welds that are subject to ultrasonic testing in addition to visual inspection shall conform to the requirements of Table 9.1.

**712.3.3.8** Milled joints shall be dressed accurately and smoothly to obtain contact throughout the depth and thickness of all component parts. The finishing of such surfaces shall be done after welding of the members is completed.

**712.3.3.9 Calibrated Tapes.** When the contract involves fabrication of a bridge with a bearing-to-bearing span of 100 feet (30 m) or more, certifications and identifying numbers of calibrated measuring tapes or numbered tapes matched to a calibrated master shall be submitted. Certification of the measuring tape to be used or certification of the master from which the tape was matched shall be traceable to the U. S. National Bureau of Standards. Certification of tapes for shop use shall be renewed at least every two years.

**712.3.3.9.1 Field Welders.** Field welders shall be qualified by a test facility with an established accredited AWS Certified Welder Program as defined in AWS Standard QC 4-89



or by an independent testing laboratory furnished by the contractor. If specimens are to be tested at an independent testing laboratory, they shall be witnessed and properly documented by the engineer. All tested specimens and radiographs, along with the laboratory's test report certifying the test results, shall be delivered to the engineer for final acceptance or rejection. If the field welder was tested and certified by a facility with an established accredited AWS Certified Welder Program as defined in AWS Standard QC 4-89, the tested specimens and radiographs will not be subject to the engineer's review. A copy of the welder's certification from the AWS test facility shall be delivered to the engineer.

**712.3.3.9.2** Qualification cards will be issued by the engineer for field welders working on Commission projects. No individual may weld on a MoDOT project unless the engineer can confirm they have continued to weld on Commission projects with the processes and in the positions for which they were initially certified without an interruption exceeding twelve months. The engineer may require recertification if there is a specific reason to question the welder's ability.

**712.3.3.10** Connection angles for floor beams and stringers shall be flush and shall be correct as to position and length of member. If milling is required, not more than 1/16 inch (1.5 mm) shall be removed from the thickness of the angles.

**712.3.3.10.1** Longitudinal girder web stiffeners shall be a single length insofar as possible. If more than a single length is necessary, such lengths shall be joined by a full penetration butt weld. The location of these butt welds shall be shown on the shop drawings for each joint and be subject to approval by the engineer. Runoff plates in compliance with AWS Section 9.25 shall be used. The welds shall be radiographically tested and accepted in accordance with the requirements of AWS Section 9.25 prior to being attached to the web.

**712.3.3.11 Pins.** Pins shall be furnished true to size and shall be straight, smooth and free from flaws. They shall be provided with hexagonal chamfered nuts. The screw ends shall be sufficiently long to permit burring the threads when members are connected. Pilot and driving nuts shall be furnished for each size of pins where required. Threads for all pins and bolts shall conform with the ANSI B1.1 Free Fit - Class 2 Series except that when recessed nuts are specified, pin ends requiring a threaded diameter of 1 3/8 inches (35 mm) or more shall have six threads per inch (25 mm). If standard nuts are specified for this size pin, a minimum of four threads to the inch (25 mm) shall be used.

**712.3.3.11.1 Pin Holes.** Pin holes shall be bored true to size, smooth and straight, at right angles to the axis of the member, and parallel with each other. The boring shall be done after the member is assembled and welded. The center-to-center distance of pin holes shall be correct within 1/32 inch (0.8 mm) for an individual component or member. The diameter of pin holes shall not exceed that of the pin by more than 1/50 inch (0.5 mm) for pins 4 inches (100 mm) or less in diameter, nor more than 1/32 inch (0.8 mm) for pins larger than 4 inches (100 mm) in diameter.

**712.3.3.12 Casting.** Castings shall be free from inclusions of foreign material, casting faults, injurious blow holes or other defects which render them unsuitable for the service intended. Castings shall be properly filleted at re-entrant angles. No tolerance will be allowed below the dimensions shown on the plans for thicknesses over an appreciable area of the casting. A reasonable oversize will not be cause for rejection.

**712.3.3.13** Bent plates shall be cold bent and so taken from the stock plates that the bend line will be at right angles to the direction of rolling. The radius of bends, measured to the concave face of the metal, shall be not less and preferably shall be greater than shown in the following table, in which "T" is the thickness of the plate:

Angle Through Which Plate is Bent	Minimum Radius
61 degrees to 90 degrees	1.0 T
Over 90 degrees to 120 degrees	1.5 T
Over 120 degrees to 150 degrees	2.0 T

**712.3.3.13.1** If a shorter radius is required, the plates shall be hot bent. Hot bent plates shall also be bent at right angles to the direction of rolling. Before hot or cold bending, the corners of the plate shall be rounded to a radius of 1/16 inch (1.5 mm) throughout that portion of the plate at which the bending is to occur.

**712.3.3.14 Surface Finish.** Bearing plates of rolled steel not requiring a surface finish shall be straightened to a plane surface. The surfaces of plates of rolled steel or cast material which are to be in contact shall be finished as shown on the plans, and the final finish shall be made in a manner to give at least 50 percent contact as indicated by standard machinist's blue test. Rockers and pedestals made from rolled steel shall be finished after welding. If a flat surface is shown on the plans, the tolerance shall be 0.003 inch per inch (0.003 mm/mm) in any direction. Flat surfaces in full contact shall be finished at right angles to each other. Bearing plates shall be assembled in sets, and each set shall be matchmarked before inspection. The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the following surface roughness requirements as defined in ANSI B46.1, Surface Roughness, Waviness and Lay, Part I:

	Micro-inches ( $\mu$ m) Max.
Steel Slabs	2000 (51)
Heavy Plates in Contact in Shoes to be Welded	1000 (25)
Milled Ends of Compression Members, Stiffeners and Fillers	500 (12)
Bridge Rollers and Rockers	250 (6)
Pins and Pin Holes	125 (3)
Sliding Bearings	125 (3)

**712.3.3.15 Horizontally Curved Rolled Beams and Plate Girders.** If the plans show rolled beams or welded plate girders to be finished to a horizontal curvature, they shall be fabricated as follows: Rolled beams shall be curved by the heat curving procedure. Welded plate girders may be fabricated by cutting the flanges to the specified curvature before they are attached to the webs or, if not prohibited by the contract, may be curved by the heat curving procedure.

**712.3.3.15.1** If the heat curving procedure is used, it shall comply with the following requirements:

(a) Material. Heat curving of rolled beams and welded plate girders shall be limited to AASHTO M 270 Grade 36 (ASTM A 709 Grade 36), AASHTO M 270 Grade 50 (ASTM A 709 Grade 50) and AASHTO M 270 Grade 50W (ASTM A 709 Grade 50W).

(b) Type of Heating. Beams and girders may be curved by either continuous or V-type heating.

(1) For the continuous method, strips along the edge of the top and bottom flanges shall be heated simultaneously. The strips shall be of sufficient width and temperature to obtain the required curvature.

(2) For the V-type heating, the top and bottom flanges shall be heated in truncated triangular or wedge-shaped areas having their bases along the flange edge and spaced at regular intervals along each flange as required to obtain the specified curvature. Heating shall progress along the top and bottom flange at approximately the same rate. The apex of the truncated triangular area applied to the inside flange surface shall terminate just before the juncture of the web and the flange is reached. If the radius of curvature is 1000 feet (300 m) or more, the apex of the truncated triangular heating pattern applied to the outside flange surface shall extend to the juncture of the flange and web. If the radius of curvature is less than 1000 feet (300 m), the apex of the truncated triangular heating pattern applied to the outside flange surface shall extend past the web for a distance equal to 1/8 of the flange width or 3 inches (75 mm), whichever is less. The truncated triangular pattern shall have an included angle of approximately 15 to 30 degrees, but the base of the triangle shall not exceed 10 inches (250 mm). Variations in the pattern specified above may be made with the approval of the engineer.

(3) For both types of heating, the flange edges to be heated are those that will be on the inside of the horizontal curve after cooling. Heating both inside and outside flange surfaces is mandatory only when the flange thickness is 1 1/4 inches (32 mm) or greater, in which case the two surfaces shall be heated concurrently. The maximum temperature shall be as specified in subparagraph (d).

(c) Control of Web and Flange Distortion. To avoid unnecessary web distortion, special care shall be taken when heating the inside flange surfaces (the surfaces that intersect the web) so that heat is not applied directly to the web. If excessive web or flange buckling is encountered, the procedure shall be modified immediately.

(d) Temperature. The heat curving operation shall be conducted under rigid controls so the temperature of the steel does not exceed 1100 F (593 C) as measured by temperature-indicating crayons or other suitable means applied before heating. The heating of the steel to a temperature greater than 1200 F (650 C) will be considered destructive heating and will be positive cause for rejection of the steel. Quenching with water or water and air, will not be permitted. Cooling with dry compressed air will be permitted after the steel has cooled to 600 F (315 C).

(e) Position for Heating. The girder may be heat curved with the web in either a vertical or a horizontal position. When curved in the vertical position, the girder shall be braced or supported in such a manner that the tendency of the girder to deflect laterally during the heat curving process will not cause the girder to overturn. When curved in the horizontal position, the girder shall be supported near its ends and at intermediate points, if required, to obtain a uniform curvature. When the girder is positioned horizontally for heating, intermediate safety catch blocks shall be maintained at the mid-length of the girder within 2 inches (50 mm) of the flanges at all times during the heating process.

(f) Sequence of Operations. Heat curving shall be completed before the girder is painted. The heat curving operation may be conducted either before or after all the required welding of transverse intermediate stiffeners is completed. However, unless provisions are made for girder shrinkage, connection plates and bearing stiffeners shall be located and attached after heat curving. If longitudinal stiffeners are required, they shall be heat curved or oxygen-cut separately and then welded to the curved girder. If cover plates are to be attached to rolled beams, the beams shall be heat curved before the cover plates are attached. Cover plates shall be either heat curved or oxygen-cut separately and then welded to the curved beam.

### **712.3.3.16 Shop Assembly and Measurement.**

#### **712.3.3.16.1 Shop Assembly.**

(a) If required by the contract, the structural steel for bridges shall be shop assembled for inspection in their entirety, supported only at points of bearing. Long bridges required to be shop assembled in their entirety may be divided into units for assembly with each unit extending from expansion device to expansion device.

(b) Beams and girders of all other bridges shall be assembled for inspection in line assemblies with a minimum length assembled of one complete span, from bearing to bearing.

(c) During shop assembly connecting parts shall be firmly fastened together and held in alignment with a minimum of four drift pins and four make-up bolts per flange splice plate, web splice plate or similar connecting part, until assembly inspection is complete.

**712.3.3.16.2 Shop Measurement of Curvature and Camber.** Horizontal curvature and vertical camber will not be measured for QA inspection in the shop until all welding, drilling and heat curving operations have been completed and the flanges have cooled to a uniform temperature. For bridges not requiring complete shop assembly, the vertical camber will be checked with the girder in a horizontal position, and the horizontal curvature will be checked with the girder in either a horizontal or vertical position. The shop drawings shall show the required off-sets for both curvature and camber at approximately 10-foot (3 m) intervals, measured along the girder. The permissible variation in specified sweep for horizontally curved beams and girders, measured in inches, but not to exceed 1/2 inch (13 mm), shall be as follows:

#### ENGLISH

1/8 inch x 0.1 x (number of feet from end bearing)

#### METRIC

3 mm x 0.1 x (number of meters from end bearing x 0.3)

The shop drawings shall show the required offsets for both curvature and camber at approximately 10-foot (3 m) intervals, measured along the girder.

**712.3.4 Shear Connector Studs.** Shear connector studs may be attached to the beams or girders either in the fabricating shop or in the field. If the shear connector studs are to be attached in the field, the contractor shall notify the engineer not less than one week before the contractor begins welding shear connectors to the beams or girders so the engineer may inspect for approval the proposed welding procedure and equipment. Only welding procedures, equipment and operators meeting the approval of the requirements of [Sec 712](#) shall be used.

**712.3.4.1** If necessary to obtain satisfactory welds, areas to which shear connectors are to be attached shall be cleaned of all foreign material such as oil, grease or paint. Cleaning may generally be done by use of wire brushes or other methods approved by the engineer. Where a shop coat of inorganic zinc primer has been applied, removal shall be limited to the minimum area necessary to apply the studs.

**712.3.5 Shipping.** Fabricated material shall not be shipped before a "Fabrication Inspection Shipment Release" is issued by the engineer. All parts shall be loaded and protected in a manner to prevent damage in transit. Loading and unloading of members shall be done with equipment adequate for the purpose. Pins, nuts, bolts and other small parts shall be boxed or

crated. The "Fabrication Inspection Shipment Release" shall be delivered to the engineer at destination prior to erection of steel.

**712.3.6 Handling, Transporting, Storing and Erecting.** Fabricated material shall be properly braced and supported at all times to prevent damage from torsional, vertical and lateral deflections. Members suspected to have been damaged during handling, transporting, storing or erecting will be subjected to nondestructive tests as ordered by the engineer. The costs of these tests shall be borne by the contractor. Fabricated structural steel shall be stored on platforms, skids or other supports. Trough sections shall be stored in a manner to provide drainage. Long members shall be supported at frequent intervals. Girders and beams shall be handled and stored in an upright position. Any material which has become bent shall be straightened before being assembled or shall be replaced if necessary. Material intended for use in the finished structure shall not be used by the contractor for erection or temporary purposes unless such use is provided for in the contract or by written approval of the engineer.

**712.4 Falsework.** Staging and falsework necessary for the erection of the structure shall be furnished and placed and, upon completion of the erection, removed by the contractor. Adequate supports shall be placed at each splice point in the lower chords of truss spans except when erection is done by the cantilever method. If required, plans for falsework shall be submitted to the engineer before starting the work, but the engineer's acceptance of the plans will not relieve the contractor of the responsibility for obtaining satisfactory results.

**712.5 Erection.** Erection of all parts of the structure shall be in accordance with the erection diagram or working drawings. Surfaces to be in permanent contact shall have all burrs and loose scale removed. Before erection, machine finished surfaces shall be cleaned of the protective coating other than the primer permitted by [Sec 712.2.7](#), and contact surfaces shall be given a heavy coat of graphite and oil. Reamed connections match-marked in the shop shall be erected in accordance with those match-marks. Interchange or reversal of reamed connections will not be allowed. Hammering which may damage or distort the members will not be permitted.

**712.5.1** Truss spans, plate girders and continuous I-beams shall be supported to maintain required camber during erection. Fitting up bolts and drift pins shall be furnished by the contractor. High strength bolted field splices and primary connections, except for trusses and structures carrying live load erection stresses, shall have not less than one-half of the holes fitted with bolts and cylindrical drift pins using one-third fitting up bolts and two-thirds pins. Splices and primary connections carrying erection traffic during erection or truss connections, shall have not less than three-fourths of the holes filled with drift pins and bolts using one-third fitting up bolts and two-thirds pins. The specified ratio of pins to bolts shall apply to each element of the splice; for example, top flange, web and bottom flange of girders. Fitting up bolts shall be the same diameter as the high strength bolts. Drift pins shall be not less than 1/32 inch (0.8 mm) larger than the high strength bolts to provide a driving fit. Fitting up bolts shall be symmetrically placed so as to draw the splice pieces tight to such extent that a thin knife edge cannot be inserted between the pieces being connected. All fitting up bolts and drift pins shall be properly installed before starting to install high strength bolts. Bolts used for fitting up shall not be used in the final assembly. Holes which do not match shall be reamed only with the approval of the engineer. Drifting which would distort the metal will not be permitted.

**712.5.2** The lead plates or preformed rubber and fabric pads shall be approximately 1/8 inch (3 mm) thick and 1/2 inch (13 mm) greater in length and width than bottom bearing plates under which they are to be placed. Lead plates shall weigh (have a mass of) approximately 8 pounds per square foot (39 kg/m<sup>2</sup>). Preformed rubber and fabric pads shall comply with the requirements of [Sec 1038.3](#). Shop drawings are not required for lead plates or preformed

rubber and fabric pads. Lead plates or preformed rubber and fabric pads are incidental to bearings and no direct payment will be made for furnishing or installing them.

**712.6 Anchor Bolts.** Anchor bolts for steel superstructures shall be set in the substructure units in accordance with the details shown on the plans. When anchor bolts are set during the placing of the concrete, they shall be accurately located and held firmly in a rigid template which spans the concrete with sufficient clearance to permit proper finishing of the surface of the concrete. The template shall remain in place until the concrete has set. Where permitted or required, the anchor bolt wells may be omitted and in lieu thereof, holes drilled into the substructure. The anchor bolt holes shall be drilled in the exact location shown, to the required depth, perpendicular to the plane of the bridge seat, and just prior to the time of setting the anchors. The drilled holes shall not be smaller than the diameter of the holes in the steel bearing plates or castings. When the anchor bolts are set in holes or wells, they shall be grouted in by using an expansive mortar meeting the requirements of [Sec 1066](#). Excess mortar forced out of the holes shall be removed. The location of anchor bolts in relation to the center of slotted holes provided in movable plates and shoes shall be varied to compensate for movement of spans due to the temperature above or below 60 F (15 C). Nuts on anchor bolts through moving parts of expansion bearings shall be adjusted to provide ample clearance for free movement of the span.

**712.7 Grouting.** Grouting under bearing plates and castings to build them to the proper grade will not be permitted. Steel shims the full size of the plate of the bearing device may be used for this purpose. The shims shall be placed between the bottom of the stringers and the top of bearing plates if practicable. Shims shall be straightened to a plane surface.

**712.8 Field Welding.** All field welding shall be performed in accordance with the applicable requirements of [Sec 712.3.3.7](#).

**712.8.1 Falsework or Supporting Devices.** Falsework or supporting devices designed to support the dead load of the beam or girder plus 100 percent shall be provided at each joint to be field welded. Falsework plans, including location of falsework bents or details of supporting and aligning devices or the contractor's alternate proposal for erection, shall be submitted to the engineer for review before shop drawings are submitted for approval. The engineer's review will not be considered as relieving the contractor of the responsibility to obtain acceptable welded joints. Field welded splices, properly aligned to produce joints acceptable to the engineer, may be welded on the ground. The contractor shall provide safe and adequate scaffolding, ladders and falsework.

**712.8.2 Welding Procedures.** Welding procedures, including pass sequences for field joints, shall be submitted to the engineer for review prior to submitting shop drawings. Weld passes shall be made symmetrically and shall alternate between both sides of the joint. The welding procedure shall indicate at what step in the welding sequence the contractor proposes to loosen or remove each alignment and support device.

**712.9 Machine Bolts.** Machine bolted field connections shall be made with machine bolts having American Standard Regular Heads and Nuts of hexagonal shape and shall conform to the requirements of ANSI B18.2.1 and B18.2.2. The threads shall extend slightly beyond the nut to permit burring. One plain washer meeting the requirements of ANSI B18.22.1 shall be used at all slotted holes.

#### **712.10 High Strength Bolts.**

**712.10.1 Bolted Parts.** The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed one in 20 with respect to a plane normal to the bolt axis. All bolted parts,

including underhead bearing areas and joint surfaces within the grip of the bolt, shall fit solidly together when assembled in the snug tight condition and shall not be separated by gaskets or any other interposed compressible material. When assembled, all joint surfaces, including those adjacent to the bolt heads, nuts or washers, shall be free of scale, dirt, burrs, other foreign material and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint (except as provided in [Sec 712.12.8](#)), lacquer, rust inhibitor and galvanizing. All bolts, nuts and washers shall be free of rust, burrs, dirt, other foreign material and other defects that would prevent proper tensioning. All nuts for coated high strength bolts shall be properly lubricated with a visible water soluble lubricant. All nuts for uncoated high strength bolts shall be properly lubricated with a water soluble lubricant that is oily to the touch.

**712.10.1.1 Snug Tightness of Connections.** Regardless of the method of final tightening used to install the fasteners, the joint and all fasteners shall first be brought to the snug tight condition. Snug tight is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a person using an ordinary spud wrench. Snug tightening shall progress systematically from the most rigid part of the connection to the free edges. The bolts shall be retightened in a similar manner as necessary until all bolts are simultaneously snug tight and the section is fully compacted with the bolted parts of the joint in full contact.

#### **712.10.2 Installation.**

**712.10.2.1 Bolt Tension.** Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension shown in Table I for the size and grade of fastener used. Threaded bolts shall be tightened by methods described in [Sec 712.10.2.3](#), [712.10.2.4](#) or [712.10.2.5](#). If required because of bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating. On non-parallel abutting surfaces where bevel washers are not required, the nut shall be torqued against the non-sloping surface. Nuts shall be placed on the inside face of exterior girders, the top of girder flanges or in other situations the least exposed position, except if inaccessible for turning, on a sloping surface or otherwise approved by the engineer. Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds. Bolts or nuts, once tensioned and subsequently loosened (turned), shall not be used as permanent bolts or nuts. Bolt tension calibration devices shall be calibrated and certified as to accuracy by a private testing lab within one year before usage or at any time the accuracy is questionable.

TABLE I			
Bolt Tension and Projection			
ENGLISH			
Bolt Size (in.)	Minimum Bolt Tension (lb x 1000)		Maximum Bolt Projection (in.)
	A-325	A-490	
1/2	12	15	1/4
5/8	19	24	3/8
3/4	28	35	3/8
7/8	39	49	3/8
1	51	64	1/2
1 1/8	56	80	1/2
1 1/4	71	102	1/2
1 3/8	85	121	1/2
1 1/2	103	148	1/2
METRIC			
Bolt Size (mm)	Minimum Bolt Tension (kN)		Maximum Bolt Projection (mm)
	A-325M	A-490M	
M16 x 2	91	114	10
M20 x 2.5	142	179	10
M22 x 2.5	176	221	10
M24 x 3	205	257	13
M27 x 3	267	334	13
M30 x 3	326	408	13
M36 x 4	475	595	13

**712.10.2.2 Washers.** All fasteners shall have a hardened washer under the nut or bolt head, whichever is turned in tightening. All fasteners over all oversized or slotted holes shall also have a hardened washer under the non-turned element. Where an outer face of the bolted parts has a slope of more than one in 20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism.

**712.10.2.3 Calibrated Wrench Method.** When calibrated wrenches are used to provide the bolt tension specified in Table I, their setting shall be such as to induce a bolt tension 5 percent to 10 percent in excess of the specified value. These wrenches shall be calibrated at least once each working day by tightening in a device capable of indicating actual bolt tension not less than three typical bolts of each diameter from the bolts to be installed. Power wrenches shall be adjusted to stall or cut out at the selected tension. If manual torque wrenches are used, the torque indication corresponding to the selected tension shall be noted and used in the installation of all bolts of the tested lot. Nuts shall be in tightening motion when torque is measured. After the joint has been brought to a snug tight condition, all bolts in the joint shall be tightened by progressing systematically from the most rigid part of the joint to its free edges. When using calibrated wrenches to install several bolts in a single joint, the wrench shall be returned to "touch up" bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the selected tension. During tightening, there shall be no rotation of the part not turned by the wrench.

**712.10.2.4 Turn-of-Nut Method.** When the turn-of-nut method is used to provide the bolt tension, there shall first be enough bolts brought to a snug tight condition as defined in [Sec 712.10.1.1](#) to ensure that the parts of the joint are brought into full contact with each other. Following this initial operation, bolts shall be placed in any remaining holes in the connection



and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable nut rotation specified in Table II with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

<b>TABLE II</b>			
<b>Nut<sup>a</sup> Rotation from Snug Tight Condition</b>			
Disposition of Outer Faces of Bolted Parts			
Bolt length measured from underside of head to extreme end of point	Bolt faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20 (bevel washer not used)	Both faces sloped not more than 1:20 from normal to bolt axis (bevel washers not used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters	2/3 turn	5/6 turn	1 turn

<sup>a</sup> Nut rotation is relative to bolts, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, the tolerance shall be plus or minus 30 degrees; for bolts installed by 2/3 turn and more, the tolerance shall be plus or minus 45 degrees.

**712.10.2.5 Load Indicating Bolt Method.** Tightening by this method is permitted provided it can be demonstrated by the following procedure that the bolt has been tightened to not less than the bolt tension indicated in Table I. Three bolts of a representative length, and of the same grade, diameter and condition as those under inspection shall be placed individually in a calibration device capable of indicating bolt tension. There shall be a washer under the part turned in tightening each bolt. Each bolt specified shall be tightened in the calibration device until the spline drive has sheared off. When this method is used to provide the bolt tension, all bolts in the joint shall be tightened in stages to prevent or minimize slackening of the installed bolts. The first stage is to tighten all bolts to a snug tight condition at which point all of the faying surfaces of the joint should be firmly in contact. The final stage of tightening to full tension shall be accomplished by progressing systematically from the most rigid part of the joint to its free edges.

**712.10.2.6 Bolt Length.** When snug tight, the beginning of the bolt threads shall be even with or project slightly beyond the nut. When properly tensioned, the bolt projection shall not exceed the maximum as specified in Table I.

**712.10.3 Inspection.** The engineer will observe the installation and tightening of bolt assemblies to determine that the selected tightening procedure is properly used and will determine that all bolt assemblies are tightened. The following verification inspection will be used:

(a) Either the engineer or the contractor in the presence of the engineer, shall use an inspecting torque wrench and bolt tension calibration device furnished by the contractor. Bolt tension calibration devices shall be calibrated and certified as to accuracy by a private testing lab within one year before usage or at any time the accuracy is questionable.

(b) Five bolt assemblies of a representative length, and of the same grade, diameter and condition as those under inspection shall be placed individually in a calibration device

capable of indicating bolt tension. There shall be a washer under the part turned in tightening each bolt. Each bolt specified shall be tightened in the device by any convenient means to the minimum tension specified in Table I. The inspecting torque wrench then shall be applied to the tightened bolt and the torque necessary to turn the nut or head 5 degrees, approximately one inch (25 mm) at 12-inch (300 mm) radius, in the tightening direction shall be determined. Of the five values obtained, the highest and the lowest values shall be disregarded, with the average of the remaining three being taken as the job inspecting torque to be used in the manner specified in [Sec 712.10.3\(c\)](#). The inspecting torque shall be re-established at intervals of not more than 30 calendar days or at any time appreciable changes are encountered.

(c) Bolts represented by the sample prescribed in [Sec 712.10.3\(b\)](#) which have been tightened in the structure will be inspected by applying, in the tightening direction, the inspecting wrench and its job inspecting torque to 10 percent of the bolts, but not less than two bolts, selected at random in each connection. If no nut or bolt head is turned by this application of the job inspecting torque, the connection will be accepted as properly tightened. If any nut or bolt head is turned by the application of the job inspecting torque, this torque shall be applied to all bolts in the connection, and all bolts whose nut or head is turned by the job inspecting torque shall be tightened and re-inspected or the contractor, at the contractor's option, may re-tighten all of the bolts in the connection and then resubmit the connection for inspection.

#### **712.11 Blank.**

#### **712.12 Protective Coating of Structural Steel.**

**712.12.1 Description.** This work shall consist of the preparation of previously uncoated structural steel surfaces, furnishing and applying specified coatings, protection and drying of coatings, furnishing protection from coating spatter and disfigurement, and final cleanup.

#### **712.12.2 Surface Preparation.**

**712.12.2.1** Oil, grease and other contaminants shall be removed with an approved solvent prior to blast cleaning. Where high strength bolts are installed prior to blast cleaning or finish coat, the lubricant on high strength bolt assemblies shall be removed with an approved solvent. Surfaces to be prime coated shall be blast cleaned with abrasives producing a height of profile 1.5 mils (38 µm) minimum and 3.0 mils (76 µm) maximum for all systems. The blast cleaned surfaces shall be completely free of all oil, grease, dirt, rust, mill scale, weld spatter and other foreign matter, except that very light shadows, streaks or slight discolorations caused by rust stain or mill scale oxides may remain. At least 95 percent of each square inch (92 square millimeters) of surface area shall be free of all visible residues, and the remainder shall be limited to the discoloration mentioned above. Surfaces shall be cleaned to a condition equal to or better than the appearance of the pictorial surface preparation standard, labeled Sa 2 1/2 in ASTM D 2200, that applies to the starting rust grade of the steel. Surfaces cleaned to meet Steel Structures Painting Council Specification SSPC-SP-10 will meet these requirements.

**712.12.2.2** After blast cleaning, the surfaces shall be brushed with clean brushes, blown off with compressed air or cleaned by vacuum to remove any trace of blast products, dust or dirt from the surface, and also from all pockets and corners. Compressors shall be equipped with moisture and oil separators, traps and filters to maintain a clean, dry, oil free air supply at the end of the hose. Separators and traps shall be of adequate size and shall be drained periodically during operations. Filters shall be checked and replaced when necessary. The blast cleaned surfaces shall be given the specified prime coat as soon as practicable, but in any case within 24 hours after blast cleaning. If blast cleaned surfaces rust before coating is

accomplished, they shall be reblasted by the contractor at the contractor's expense. All rusted, damaged or uncoated areas, including ungalvanized nuts, bolts and washers to be prime coated in the field, shall be blast cleaned to the same degree as specified above for the applicable coating system. Care shall be exercised to ensure the blasted steel remains free of grease and oil during handling.

**712.12.2.3** When there is contamination of any surface to be coated, all dirt, oil, grease, oxidation products and other detrimental foreign matter shall be removed to the satisfaction of the engineer. If these contaminants cannot be removed by other methods, the contractor shall remove all oil and grease by scrubbing with an approved solvent, blast cleaning the rejected areas of all previously applied coatings and recoating in accordance with these specifications.

**712.12.3 Systems of Coatings.** The required system and color or choice of systems and color will be specified on the plans. Each coat of the specified system shall be applied to all structural steel, unless the contract specifically delineates otherwise. The system and color of coating to be shop-applied shall be shown on the shop drawings. All coatings shall comply with local VOC (Volatile Organic Compound) regulations where the paint is applied. The system and color shall not vary for any portion of the entire structure, including material for field repairs, and shall be compatible products of a single manufacturer. The contractor shall coordinate the various items of work to assure compliance with the requirements of this section. All structural steel shall be coated with one of the following systems:

<b>System F (High Solids, Inorganic Zinc Silicate)</b>		
<b>Coating</b>	<b>Specification</b>	<b>Dry Film Thickness mils (µm)</b>
Prime Coat	<a href="#">Sec 1045.5</a>	3.0 (75) min.-6 (150) max.
<b>System G (High Solids, Inorganic Zinc Silicate-Epoxy-Polyurethane)</b>		
<b>Coating</b>	<b>Specification</b>	<b>Dry Film Thickness mils (µm)</b>
Prime Coat	<a href="#">Sec 1045.5</a>	3.0 (75) min.-6 (150) max.
Epoxy Intermediate Coat	<a href="#">Sec 1045.6</a>	3.0 (75) min.-5 (125) max.
Polyurethane Finish Coat, Gray or Brown	<a href="#">Sec 1045.7</a>	2.0 (50) min.-4 (100) max.
<b>System H (High Solids, Inorganic Zinc Silicate-Waterborne Acrylic Intermediate-Waterborne Acrylic Finish)</b>		
<b>Coating</b>	<b>Specification</b>	<b>Dry Film Thickness mils (µm)</b>
Prime Coat	<a href="#">Sec 1045.5</a>	3.0 (75) min.-6 (150) max.
Waterborne Acrylic, Intermediate Coat	<a href="#">Sec 1045.8</a>	2.0 (50) min.-4 (100) max.
Waterborne Acrylic, Finish Coat, Gray or Brown	<a href="#">Sec 1045.8</a>	2.0 (50) min.-4 (100) max.

**712.12.3.1** Unless otherwise indicated on the plans, the application of the intermediate and finish coats for Systems G and H shall be field applied over the prime coat on the structure within the following limits:

(a) The field coating for beam and girder span structures shall include the fascia girders or beams. The limits of the fascia girders or beams shall include the bottom of the top exterior flanges, top of bottom exterior flanges, the exterior web area, the exterior face of the

bottom flange and the bottom of the bottom flange. Areas of steel to be in contact with concrete shall not receive the intermediate and finish coats. The field coating shall also be applied to the exterior bearings, except where bearings will be encased in concrete.

(b) The surfaces of all structural steel located under expansion joints of beam and girder span structures shall be field coated for a distance of 1-1/2 times the girder depth, but not less than 10 feet (3 m), from the centerline of the joint. Within this limit, the items to be field coated shall include all surfaces of beams, girders, bearings, diaphragms, stiffeners and miscellaneous structural steel items. Areas of steel to be in contact with concrete shall not receive the intermediate and finish coats. The limits of the field coating shall be masked to provide crisp, straight lines and to prevent overspray on adjacent areas.

(c) For structure types other than beam and girder structures, including trusses, the above limits shall not apply and all structural steel for the entire structure shall be field coated, except the areas of steel to be in contact with concrete.

**712.12.3.2** The dry film thickness of the coatings will be measured by magnetic type gauges in accordance with MoDOT Test Method T45. At the option of the engineer, the adhesion of the prime coat will be measured in accordance with ASTM D 3359, Test Method A. When the adhesion is tested, each test result shall equal or exceed scale 3A. Locations for adhesion tests will be randomly selected. Test locations shall be in areas of least visibility in the completed structure and shall be touched up in an approved manner after completion of the test. When satisfactory test results are not obtained, additional adhesion tests shall be taken to determine the area of insufficient adhesion. For these areas, the surface shall be prepared in accordance with [Sec 712.12.2.1](#) and the area recoated in accordance with these specifications.

**712.12.3.2.1** If additional prime coat is required to provide the specified minimum thickness, it shall be applied as soon as possible but within 24 hours of the initial application.

**712.12.3.3 Coating Material Storage.** All coating material shall be stored in a manner which will protect them from the effects of the elements, away from direct sunlight. Exposure to storage temperatures outside the range recommended in the coating manufacturer's written specifications will be cause for rejection of the material. For those material for which the manufacturer has established a shelf life, each container shall be stamped by the manufacturer with an expiration date after which the material shall not be used.

#### **712.12.4 Weather Conditions.**

**712.12.4.1** The prime coat shall not be applied when the temperature of the air is less than 34 F (1 C) or greater than 110 F (43 C), nor when the temperature of the metal is less than 34 F (1 C) or greater than 130 F (54 C). The prime coat shall not be applied when the relative humidity is less than 30 percent or greater than 90 percent. Finish and intermediate coats applied over the prime coat shall be applied in accordance with the manufacturer's written specifications, which shall be furnished to the engineer.

**712.12.4.1.1** The minimums and maximums or additional requirements established by the coating manufacturer's written specifications for recommended air or metal temperature or relative humidity shall apply if they are more restrictive than those specified herein.

**712.12.4.2** Coatings shall not be applied in rain, snow, fog or mist or when the steel surface temperature is at or below 5 F (-15C) above the dew point. The dew point will be determined in accordance with MoDOT Test Method T38. Coatings shall not be applied to wet, damp, frosted or ice-coated surfaces.

**712.12.4.3** When coatings are applied in a protected area to eliminate the above conditions, the coated steel shall remain in the protected area until the coatings are cured.

**712.12.4.4** Any uncured coatings exposed to freezing, excess humidity, rain, snow, condensation or curing temperatures outside the range recommended by the manufacturer shall be considered damaged. Damaged coatings shall be permitted to dry, then be removed and the surface blast cleaned and recoated.

**712.12.5 Thinning.** Thinners are permitted as recommended by the manufacturer's written specifications, provided VOC limits are not exceeded.

**712.12.6 Tinting.** If successive coats of the same color and the minimum thickness for each successive coat are specified, alternate coats shall be sufficiently tinted to produce enough contrast in wet film to indicate complete surface coverage. If the first coat is to be approximately the color of the cleaned steel, the coating material shall be tinted. Tinting material shall be compatible with the coating and not detrimental to its service life. Tinting is not required between successive prime coats, provided enough contrast exists in wet film to indicate complete coverage.

**712.12.6.1** For partial application of intermediate and finish coats for Systems G and H as outlined in [Sec 712.12.3.1](#), the tint of the prime coat shall be similar to the color of the field coat to be used.

**712.12.7 Application.** Coatings shall be applied by brushing, air spraying, airless spraying, rolling or a combination of these methods as required to meet all specified requirements and for a uniform application free from runs, sags and holidays. Daubers or sheepskins shall be used when no other method is practicable for proper application in places of difficult access. The manufacturer's written specifications for application shall be submitted to the engineer for review. Coatings shall be applied in accordance with the manufacturer's written specifications, but shall be compatible with the following requirements:

(a) After initial mixing, primer shall be strained through a screen not coarser than 30 (600  $\mu$ m) mesh nor finer than 60 (250  $\mu$ m) mesh.

(b) Unused primer may be mixed and used within eight hours following initial mixing so long as the pigment can be easily redispersed, unless indicated otherwise by the manufacturer's written specifications. For material where the manufacturer has established a pot life after mixing, the primer shall be applied in the specified time or be discarded.

(c) If deficiencies in the quality of work or material result in rejection, the contractor shall blast clean the entire rejected areas of all previously applied coatings and recoat in accordance with requirements of these specifications, unless otherwise approved by the engineer.

(d) After the initial mixing and until application of primer, the mixture shall be kept under constant agitation.

**712.12.7.1 Spray Application.** The equipment used shall be capable of properly atomizing the coating to be applied and shall be equipped with suitable pressure regulators and gauges. Spray equipment shall be kept sufficiently clean so that dirt, dried coating material and other foreign material are not deposited in the coating film. Traps, separators or filters shall be provided to prevent oil, water and other foreign material from being deposited in the coating film. Traps and separators shall be drained periodically, and filters shall be replaced periodically. Any solvents left in the equipment shall be completely removed before

application. Ingredients shall be kept properly mixed during coating application by continuous mechanical agitation in the spray pots or containers. When coatings are spray-applied, all runs and sags shall be brushed out immediately. Blind sides of bolts and other areas inaccessible to the spray gun shall be coated by brush, daubers or sheepskins prior to spray application.

**712.12.7.2 Brush Application.** Brushes shall be of a style and quality that will enable proper application of the coating. Flat brushes shall not exceed 5 inches (125 mm) in width. Coatings shall be worked into all crevices and corners. Surfaces not accessible to brushes shall be coated by spray, daubers or sheepskins. All runs or sags shall be brushed out immediately.

**712.12.7.3 Roller Application.** Rollers shall be of a style and quality that will enable proper application of the coating and all runs or sags shall be brushed out immediately. The roller nap shall be such as to leave a smooth surface. Surfaces not accessible to rollers, including crevices and corners, shall be coated by spray, brushes, daubers or sheepskins.

**712.12.7.4 Curing of Coatings.** Curing time for recoating shall be within the limits of the manufacturer's written specifications except as modified by [Sec 712.12.3.2.1](#) for successive applications of prime coat. Application of the finish coat over the intermediate coat shall be accomplished within the recoat time for proper adhesion established by the manufacturer's written specifications. Regardless of manufacturer's specifications, the finish coat shall be applied within seven days after application of intermediate coats.

**712.12.8 Shop Coating.** All surfaces of fabricated structural steel, including areas which will be inaccessible after assembly, contact surfaces of high strength bolted connections, and all surfaces to be in contact with concrete in the completed structure shall be coated in the shop with the prime coat. The primer shall be of the type and thickness specified, except as modified by [Secs 712.12.8.1](#) and [712.12.8.2](#). Structural steel sway bracing for substructure may be prepared and coated in the field.

**712.12.8.1** Contact surfaces of high strength bolted connections shall be prime coated to produce a dry film thickness of not less than 1.5 mils (40  $\mu\text{m}$ ) nor more than 2.5 mils (65  $\mu\text{m}$ ). The maximum limit of 2.5 mils (65  $\mu\text{m}$ ) may be increased provided acceptable test results in accordance with the Testing Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints (AISC "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts", Appendix A) are submitted and approved by the engineer. The tests shall meet the requirements for the slip coefficient and creep resistance for Class B coatings and shall be performed by a nationally recognized independent testing laboratory. Any change in the formulation of the coating will require retesting, except when thinned within the limits of manufacturer's written specifications. At the contractor's option, the contact surfaces of connections for all non-slab bearing diaphragms on non-curved girders shall be prime coated with a dry film thickness of not less than 3.0 mils (75  $\mu\text{m}$ ) nor more than 6.0 mils (150  $\mu\text{m}$ ), unless noted otherwise on the design plans. Contact surfaces of high strength bolted connections shall be protected from contamination by the intermediate and finish coats.

**712.12.8.2** Surfaces which will not be in contact, but which will be inaccessible after assembly, shall be prime coated to produce a dry film thickness of not less than 3.0 mils (75  $\mu\text{m}$ ) nor more than 6.0 mils (150  $\mu\text{m}$ ). Dry film thickness on surfaces which will be in contact with concrete may be reduced to 2.0 mils (50  $\mu\text{m}$ ) provided thorough and complete coverage is obtained. Although shear connectors need not be coated when a field coat will be applied, it is not necessary to protect them from overspray when coating other parts of the beam or girder. Where a field coat will not be applied to the entire structure, the shear

connectors shall be coated to ensure complete coverage. Coating thickness measurements will not be made on shear connections.

**712.12.8.3** The inside surfaces of bolt holes shall be coated to ensure complete coverage, unless a field coat will be applied to the entire structure. Coating thickness measurements will not be made.

**712.12.8.3.1** The galvanized coating of nuts, bolts and washers damaged during shop installation shall be shop repaired in accordance with [Secs 712.12.9.1](#) and [712.12.9.1.1](#).

**712.12.8.4** No coatings shall be applied before shop inspection of fabrication has been completed. Surfaces of steel within 2 inches (50 mm) of edges to be field welded shall not be coated in the shop.

**712.12.8.5** For areas where a field coat will be applied, erection marks and match marks shall be painted upon surface areas after application of the shop coat in locations as approved by the engineer. Material shall not be loaded for shipment until the coating has cured.

**712.12.8.5.1** For areas where a field coat will not be applied, erection and match marks shall be located in areas of least visibility in the completed structure. Where it is impossible to locate erection and match marks in low visibility areas, the marks shall be touched up in the field.

**712.12.9 Field Coating.** Intermediate and finish coats for the specified coating system shall be applied in the field. The contractor shall also be responsible for final cleanup and field touch-up of any shop applied coating, including surface preparation and coating of field connections, welds or bolts, areas masked in the shop and all damaged or defective coating and rusted areas. Surface preparation for field touch-up shall be performed as specified in [Sec 712.12.2](#) unless otherwise approved by the engineer. The touch-up field coat shall be made with the same coating used for the shop applied coat. Damage to the coating of galvanized bolts, nuts and washers where bare steel is exposed shall be repaired in accordance with these specifications or, at the option of the contractor, the connection can be prepared as specified in [Sec 712.12.2](#) followed by a touch-up field coat application of the required coating system.

**712.12.9.1** The galvanized coating of nuts, bolts and washers damaged during installation shall be repaired. Lubricants shall be removed by solvent cleaning, removal of rust using hand tool cleaning in accordance with SSPC-SP-2 or power tool cleaning in accordance with SSPC-SP-3 and application of an approved aluminum epoxy mastic or an organic zinc-rich epoxy. The touch-up material shall be compatible with and from the same manufacturer as the coating system to be used for the structure. Prior to field coating operations, the contractor shall submit information on the specific products to be used, including compatibility data and applicable recoating times to the engineer for review. Subsequent coatings shall be applied within the recoat time recommended by the manufacturer.

**712.12.9.1.1** For areas of the structure that will not receive a field coat, the color of the touch-up material for bolts specified in [Sec 712.12.9.1](#) shall be similar to galvanized metal.

**712.12.9.1.2** If repairs to the galvanized coating of shop-installed nuts, bolts and washers have previously been performed in accordance with [Sec 712.12.8.3.1](#) or if epoxy mastics are otherwise shop-applied to structural steel, the contractor shall be responsible for any special field preparation required for proper adhesion of subsequent field coats to the epoxy coating. Prior to field coating operations, the contractor shall submit manufacturer's recommendations to the engineer.

**712.12.9.1.3** Previously coated or adjacent areas shall be masked or otherwise protected from material used to touch-up the galvanized coating of fasteners.

**712.12.9.2** Field coatings, except for touch-up and coating of inaccessible surfaces, shall not be applied until the concrete deck has been placed, the forms removed, and all concrete spatter and all foreign material and contaminants are removed from existing coatings. The sequence of work shall be arranged to provide ample time for each coat to cure before the next coat is applied. In no case shall a coat be applied until the previous coat has been approved by the engineer. Excessive rust streaks or coatings on concrete masonry shall be removed by sandblasting or by other approved methods, without damage to the masonry.

**712.12.9.3 Work Under Stage Construction Contracts.** If complete field coating is not included in the contract for erection of structural steel, the touch-up coating of newly erected work and the coating of surfaces which will be inaccessible after erection shall be included as part of the work to be performed under the contract for erection. Field coating under any contract that does not include the erection shall include cleaning, preparation of any previously applied coatings, repairs and spot application of coatings required at the time the work is performed.

**712.12.9.3.1** Prior to field coating of structural steel which was erected under a previous contract, the contractor shall submit manufacturer's recommendations to the engineer which shall outline requirements for cleaning and preparation of all existing coatings. These shall include requirements for preparation of organic epoxies or epoxy mastics previously applied for touch-up or other purposes.

**712.12.9.4** If partial application of the field finish coats to a structure as outlined in [Sec 712.12.3.1](#) is required or permitted, the contractor shall be responsible for field touch-up coating to areas of the structural steel outside the limits to receive the intermediate and finish coats. Touch-up shall be as specified in [Sec 712.12.9](#), and no direct payment will be made.

**712.12.10 Identification.** The contractor shall, at the completion of the coating application, stencil in black paint on the structure the number of the bridge, the word "COATED", the system used and the month and year the coating was completed. The letters shall be capitals approximately 3 inches (75 mm) high. The legend shall be stenciled on the outside face of an outside stringer or girder near each end of the bridge as specified by the engineer.

**712.12.11 Property and Traffic Protection.** The contractor shall protect pedestrian, vehicular, railroad and other traffic, persons and property, upon, beneath and in the vicinity of the structure, and all portions of the bridge against damage or disfigurement by blast media, blast residue, coatings, coating material, equipment or by any other operations.

## **712.13 Recoating of Structural Steel.**

**712.13.1 Description.** This work shall consist of field preparation of structural steel surfaces to be recoated, furnishing and applying specified coatings, protection and drying of coatings, furnishing protection from coating spatter and disfigurement and final cleanup.

**712.13.2 Systems of Protective Coatings.** All structural steel shall be recoated by the contractor in the field using one of the complete systems, including prime coats, as specified in [Sec 712.12.3](#), unless noted otherwise. Recoating of structural steel including surface preparation, weather conditions, application, touch-up and protection shall be in accordance with all requirements of [Sec 712.12](#).



**712.13.3 Surface Preparation.** Surface preparation shall be in accordance with [Sec 712.12.2](#). Oil, grease and other contaminants shall be removed with an approved solvent prior to blast cleaning. All existing coatings and paint shall be removed by blast cleaning unless specifically indicated otherwise in the contract.

**712.13.4** All seams and joints which cannot be satisfactorily sealed or coated shall be adequately caulked with compounds compatible with the coating system being applied. Caulking material shall comply with the coating manufacturer's recommendations and meet the approval of the engineer. Caulking shall be satisfactorily completed for an entire joint or seam after application of the prime coat and before application of any specified finish or intermediate coats.

**712.13.5 Identification.** The contractor shall, at the completion of recoating, stencil in black paint on the structure the number of the bridge, the word "RECOATED", the system used and the month and year the coating was completed. The letters shall be capitals approximately 3 inches (75 mm) high. The legend shall be stenciled on the outside face of an outside stringer or girder near each end of the bridge as specified by the engineer.

**712.14 Galvanized Metal.** Galvanizing shall be done after fabrication. Galvanized material on which the galvanizing has been damaged will be rejected or may, with approval of the engineer, be repaired in the field by the zinc alloy stick method. Required field welds and adjacent areas on which galvanizing has been damaged shall be galvanized by this same method. The zinc alloy stick shall be cast from zinc, tin and lead in combination with fluxing ingredients. The compound shall be completely liquid at a temperature not lower than 475 F (246 C). The area to be regalvanized shall be thoroughly cleaned, including the removal of slag on welds. The surface shall be heated with a torch to approximately 600 F (315 C), and the alloy stick rubbed over the surface to fix a deposit. While the alloy is still liquid, a clean wire brush shall be used to smooth the deposit evenly over the entire area being regalvanized. If a heavy deposit or build-up is required to match the original coating, more alloy shall be added immediately to the initial bond deposit and spread with a paddle or brush until the required thickness is obtained.

**712.15 Steel Bar Dams.** Steel bar dams placed at expansion devices on existing bridges to serve as headers for surfacing material shall be installed in a manner that will not interfere with the movement of the expansion devices.

**712.16 Method of Measurement.**

**712.16.1** Payment for structural steel and wrought iron weights (masses) will be based on plan quantities. The theoretical weight (mass) of the various sections will be used to compute the plan quantities of the material incorporated in the completed structure. No allowance will be made for overrun in scale weights (masses) or for erection bolts, excess field bolts or similar items, or the weight (mass) of any coating, galvanizing or weld material.

**712.16.2** The weight (mass) of steel bolts for steel to steel connections will be included in the plan quantities for fabricated structural steel on the basis of following weights (masses) per 100 bolts:

ENGLISH	
Bolt Size (in.)	Weight (lb)
5/8	40
3/4	65
7/8	95
1	135
METRIC	
Bolt Size (mm)	Mass (kg)
M16	15
M20	30
M22	43
M24	55
M27	75
M30	100

These specified weights (masses) will be considered to cover the head, nut, any required washers and only that part of the bolt extending outside the grip of steel.

**712.16.3** The weight (mass) of bolts connecting steel to concrete or steel to timber will be included for payment as fabricated structural steel and the full weight of the bolts will be computed.

**712.16.4** Bolts for attaching timber members to any part of a structure will be classified as hardware and no direct payment will be made.

**712.16.5** Castings will be computed on the basis of the theoretical weight (mass) of the material in the completed structure, and no allowance will be made for overrun in scale weights (masses) or for the weight (mass) of any coating material, galvanizing material or other protective coatings.

**712.16.6** Weights (Masses) of structural steel, wrought iron and castings will be computed to the nearest 10 pounds (5 kg) of the total weight (mass) of each class of material in the completed structure.

**712.16.7** If coating of steel structures is specified as a contract item, the method of payment will be included in the contract.

**712.16.7.1** If the contract specifies a unit of measurement of coating steel structures in tons (megagrams), the weight (mass) of the steel to be cleaned and coated will be based on plan quantities to the nearest 1/10 ton (0.1 Mg). The weight (mass) will not vary with the number of coats applied.

**712.16.7.2** If the contract specifies a unit of measurement of coating steel structures in square feet (square meters), the area will be computed to the nearest 100 square feet (10 m<sup>2</sup>) of structural steel to be field coated. The area computations are approximate and do not include diaphragms, stiffeners and all other miscellaneous steel within the limits of the field coatings. The area will not vary with the number of coats applied. Final measurement will not be made.

**712.16.8** If recoating of steel structures is specified as a contract item, the method of measurement will be included in the contract. The contract will indicate the estimated number of tons (megagrams) to be coated for informational purposes.

**712.16.8.1** Measurement will not be made when the contract specifies units of measurement per lump sum.

**712.16.8.2** If the contract specifies a unit of measurement of surface preparation or recoating steel structures in square feet (square meters), the area will be computed to the nearest 100 square feet (10 m<sup>2</sup>) of girders to be recoated. The area computations are approximate and do not include bearings, diaphragms, stiffeners and all other miscellaneous steel within the limits of the field coating. The area will not vary with the number of coats applied. Final measurement will not be made.

**712.16.9** A steel bar dam consists of the complete assembly on both sides of the expansion joint and will be considered a unit.

**712.16.10** The weight (mass) of shear connectors will be based on the theoretical weight (mass) and will be included for payment in the weight (mass) of material to which the connectors are attached.

**712.17 Basis of Payment.**

**712.17.1** Payment for fabricated structural steel, fabricated wrought iron, steel castings and gray iron castings will be based on the plan quantities. Any change in the plan quantities based on approved change orders will be paid for at the contract unit price. Payment for the shop prime coat including inaccessible areas shall be included in the cost of fabricated structural steel, otherwise no direct payment will be made. No direct payment will be made for coating of bolted field connections, touch-up, galvanizing, applying protective coating to machined surfaces or for cleaning coatings and rust streaks from finished concrete.

**712.17.2** If specified as a contract item, the accepted quantity of coating structural steel will be paid for at the contract unit price for coating, except that the cost of shop applied coats shall be included in the cost of the fabricated structural steel, otherwise no direct payment will be made. No direct payment will be made for stencils, paint and painting specified in [Sec 712.12.10](#). No direct payment will be made for field touch-up specified in [Sec 712.12.9](#).

**712.17.3** The accepted quantity of recoating will be paid for at the contract unit price for recoating each bridge specified in the contract. No direct payment will be made for stencils, paint and painting specified in [Sec 712.13.5](#). No direct payment will be made for field touch-up specified in [Sec 712.12.9](#).

**712.17.4** The accepted number of steel bar dams will be paid for at the contract unit price.

## SECTION 713

### BRIDGE GUARDRAIL

**713.1 Description.** This work shall consist of furnishing and erecting steel beam guardrail as shown on the plans, including beams, posts and all appurtenances.

**713.2 Material.**

**713.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Guardrail Material	<a href="#">1040</a>

**713.3 Construction Requirements.** Anchor bolts for posts shall be set with suitable templates in exact position and securely fixed to prevent displacement during the concreting operations. If posts are to be set on concrete, the areas upon which their bases are to bear shall be dressed smooth to a true plane by grinding or rubbing. Posts shall be aligned by the use of shims so that in final adjustment no post shall deviate more than 1/8 inch (3 mm) from true alignment.

**713.4 Method of Measurement.** Measurement of bridge guardrail will be made to the nearest linear foot (0.5 m) for each structure, measured along the face of the beam and from center to center of end posts. Final measurement of the completed bridge guardrail will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**713.5 Basis of Payment.** The accepted quantity of bridge guardrail, complete in place, will be paid for at the unit price for each of the pay items included in the contract.

## SECTION 714

### ALUMINUM RAIL - TUBE TYPE

**714.1 Description.** This work shall consist of furnishing and erecting cast aluminum rail posts and extruded aluminum alloy tubes for railings on bridges, roadway medians and retaining walls.

#### **714.2 Material.**

**714.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Bearing Pads	<a href="#">1038.4</a>
	<b>Specification</b>
Aluminum Alloy Extruded Tubes and Bars	ASTM B 221 Alloy 6061-T6*
Steel Bolts and Nuts	ASTM A 307
Aluminum Shims	ASTM B 209 Alloy 1100-0
Stainless Steel Screws and Washers	ASTM A 193 Austenitic Steel with minimum yield of 30,000 psi (207 MPa)
Stainless Steel Set Screws	ASTM A 276
Cast Aluminum Posts	ASTM B 108 Alloy 356.0-T6
High Strength Cast Aluminum Posts	ASTM B 108 Alloy A444.0-T4
End Caps	ASTM B 26 Alloy B443-F or ASTM B 108 Alloy B443-F

\*Alloy 6063-T6 may be used for the 4-inch (100 mm) outside diameter by 1/8-inch (3 mm) thick bridge rail.

**714.2.2** Two certified copies of mill and foundry test reports giving the typical chemical composition from ingot production and the specific mechanical properties of the tube and casting material shall be submitted to the engineer prior to any request for shop inspection, or prior to shipment to the project site for field inspection. The reports shall show the number of each heat involved, the quantity taken from each heat, and the project for which the material is being furnished.

**714.2.3** Aluminum tubing for the horizontal members of the rail shall be extruded tubes of the size and shape shown on the plans. The tubes shall be uniform in quality and temper. Exterior and interior surfaces shall be smooth and free of laminations, cracks and other defects.

**714.2.4** Anchor bolts, nuts and washers shall be of structural steel, galvanized in accordance with the requirements of AASHTO M 232, or they may be mechanically galvanized. If

mechanically galvanized, the coating thickness, adherence and quality requirements shall conform to AASHTO M 232, Class C.

**714.2.5** Material for insulating the bases of rail posts from concrete shall be an aluminum impregnated light colored caulking compound of the consistency of putty, or 1/8 inch (3 mm) thick bearing pads meeting the requirements of [Sec 1038.4](#).

### **714.3 Fabrication and Inspection.**

**714.3.1** Shop drawings of the rail and rail posts will be required, in general, as outlined in [Sec 712.3.2](#) for shop drawings for structural steel.

**714.3.2** Fabrication of aluminum alloy material shall, in general, conform to or be equivalent to fabrication methods and practices recommended in the handbooks of the major producers of aluminum material and specifically to the following requirements:

- (a) Material shall be sawed, routed or milled. Flame cutting shall not be used.
- (b) Tubing may be heated to a temperature not exceeding 400 F (205 C) for a period not exceeding 15 minutes to facilitate bending. Bending shall be performed in the shop to the radius shown on the plans.
- (c) Holes in tubing shall be drilled. Holes in casting shall be cored, or drilled from the solid.
- (d) Welding will not be permitted except where specifically required by the specifications or on the plans. Welding shall be done by the inert gas shielded arc method using filler material meeting the requirements of AWS A5-10, Class ER5356 or ER5556.

**714.3.3** Tubing for rails shall be fabricated in lengths of two or more rail panels. No special finish is required on tubing, but exterior surfaces shall be reasonably free from dark streaks or discoloration. End closures shall be made either with plates welded in place and ground smooth, or with cast end caps having a driving fit. Grinding marks shall be removed in the shop or field and the surface shall be left in a condition matching the tubing. The fabrication and handling of aluminum material in the shop and field shall be performed in a manner to prevent scoring or marring of the surfaces. Objectionable appearance resulting from scoring or marring will be cause for rejection.

**714.3.4** The finishing of rail posts shall be performed after fabrication is completed. All fins, pipes, other casting irregularities, and all drilling, reaming, welding and other fabrication marks shall be removed. The surfaces shown on the plans shall be polished to not less than a 120 grit finish. Discoloration of the finished post will be cause for rejection.

**714.3.5** Shop inspection of rail tubes will in most cases be waived, but the tubes will be subject to inspection at the project site. Shop inspection of rail posts will be made at the foundry to establish a satisfactory class of finish and acceptability of fabrication or, at the option of the engineer, one sample post from each lot or heat, or for each structure may be sent to the engineer for approval. If this post is acceptable, it will be delivered to the project site and used as a standard for the acceptance of the remaining posts required for that structure.

**714.3.6 Quality Control for Molds.** Permanent molds shall be used for rail post castings unless specific permission is obtained to use sand molds. Castings for both the ornamental type and the high strength rail posts shall be produced under 100 percent radiographic control

and shall be X-ray inspected until a foundry technique has been established for each mold which will ensure production of castings acceptably free from harmful defects.

#### **714.3.7 Quality Control for High Strength Rail Posts.**

**714.3.7.1** After an acceptable foundry technique has been established, at least four posts from each lot shall be X-ray inspected for quality control. For each post failing to meet the X-ray requirements, two additional posts shall be X-ray inspected. If further rejections are encountered, the whole lot will be rejected, or each post shall be X-ray inspected. Areas to be inspected are the bottom 5 inches (125 mm) of tension and compression flanges, and the base of castings. One X-ray exposure representative of each of these three areas will be considered sufficient.

**714.3.7.2** For high strength rail posts, a lot of castings shall consist of not more than 60 one-tube or 50 two-tube posts, or the castings produced from each batch of a batch-type furnace, or the castings produced during a period not exceeding eight consecutive hours from a continuous furnace. At least one representative sample of each lot of castings, or one for each structure, shall be analyzed to determine conformance with the requirements for the mechanical properties and chemical composition. Two certified copies of the foundry or testing laboratory's report shall be furnished the engineer.

**714.3.7.3** Specimens for tensile tests shall be machined from the specified area of the tension flanges and all testing shall be performed in accordance with the requirements of Federal Standard 151A, Method 211.1 and shall be certified by the foundry or testing laboratory. The largest possible round specimen shall be used. Flat specimens shall be used only when the casting thickness will not permit the extraction of at least an R3 specimen. If any test specimen fails to meet the requirements, two additional specimens may be selected to replace each specimen which failed. The two replacement specimens shall meet the requirements or the lot of castings which they represent will be rejected.

**714.3.7.4** Radiographic acceptance levels for critical areas shall be based on the requirements of ASTM E 155 and the following acceptance standards:

Type of Defect	Reference Radiograph Plate Designation	Acceptance Standard Casting Thickness	
		1/2 in. (13 mm) and under	Over 1/2 in. (13 mm)
Gas Holes	1.1	2	3
Gas Porosity (round)	1.21	3	2
Gas Porosity (elongated)	1.22	2	2
Shrinkage Cavity	2.1	2	-
Shrinkage (sponge)	2.2	2	2
Foreign Material (less dense)	3.11	3	3
Foreign Material (more dense)	3.12	2	1

NOTE: (1) Presence of one or more types of defects greater than indicated by the above acceptance standards shall be cause for rejection of the casting.

(2) Presence of defects equal to but not greater than shown in the acceptance standards shall be limited to a total of two each of all types of defects, or three of any one type.

Two copies of certifications that X-ray inspection has been performed and meets the requirements for each lot shall be furnished the engineer.

#### **714.4 Construction Requirements.**

**714.4.1** Anchor bolts for rail posts shall be set with suitable templates in the specified position and securely fixed to prevent displacement during the concreting operations. The area of concrete upon which posts are to be set shall be dressed by grinding or rubbing to a true plane for the proper seating of the posts. The base of the rail posts shall be insulated from the concrete on which it is seated by the use of a bearing pad, or by a liberal coating of a caulking compound meeting the requirements of [Sec 714.2.5](#).

**714.4.2** Rail posts shall be erected in groups corresponding to the length of each rail tube. The rail shall then be aligned and the nuts on the anchor bolts tightened. In final adjustment, no post shall deviate more than 1/8 inch (3 mm) from true alignment and there shall be no abrupt break in grade or alignment of the finished rail. Aluminum shims for adjustments may be slotted.

**714.5 Method of Measurement.** Measurement of aluminum rail will be made to the nearest linear foot (0.5 m) of rail for each structure, measured along the top of the parapet from end to end of tubing. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**714.6 Basis of Payment.** The accepted quantity of aluminum tube-type bridge rail, complete in place, will be paid for at the unit price for each of the pay items included in the contract.



## SECTION 715

### VERTICAL DRAIN AT END BENTS

**715.1 Description.** This work shall consist of furnishing and installing a vertical drain with a discharge pipe as shown on the plans.

**715.2 Material.**

**715.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Geocomposite Drainage Material	<a href="#">1012</a>
Drainage Material	<a href="#">1013</a>
Corrugated Metallic-Coated Steel Pipe	<a href="#">1022</a>
Corrugated Aluminum Alloy Pipe	<a href="#">1025</a>

**715.2.2 Drain Pipe.** Drain pipe shall be of the type and diameter as shown on the plans and shall comply with the requirements as specified herein.

**715.3 Construction Requirements.**

**715.3.1** The contractor shall furnish the engineer at least two weeks prior to installation a copy of the manufacturer's printed instructions for installing the vertical drain. Except as herein noted, the installation of the drain shall be in accordance with the manufacturer's printed instructions.

**715.3.2** During all periods of shipment and storage, the drain shall be wrapped and protected from direct exposure to sunlight, ultraviolet rays, mud, dirt and debris. The vertical drain shall not be exposed to sunlight for more than 14 days total until covered with soil, rock, concrete, etc.

**715.3.3** If the core of the drain is not perforated, 1/2 inch (13 mm) diameter holes shall be punched or drilled on 6 inch (150 mm) centers approximately 3 inches (75 mm) from the bottom of the drain or approximately at the centerline of the drain pipe.

**715.3.4** Vertical and horizontal joints shall be constructed so as to form an uninterrupted drain face after compaction is completed. All joints shall have an overlap of geotextile to prevent any intrusion of fill material into the drain. Horizontal joints shall be designed to drain downward. Any cracks or openings in the drain adjacent to the fill will be cause for rejection and replacement of the drain.

**715.3.5** Care shall be taken to secure the 6 inch (150 mm) flaps of geotextile over the top and bottom of the drain as shown on the plans.

**715.3.6** A rodent screen shall be inserted inside the outlet pipe 6 to 12 inches (150 to 300 mm) from the outlet coupler.

**715.3.7** The backfill material shall be placed and compacted in accordance with [Sec 206](#). The backfill shall be placed in a manner to prevent damage to the drainage system. The backfill material and approach pavement shall be as approved by the engineer.

**715.4 Basis of Payment.** The accepted drainage system, complete in place, will be paid for at the contract unit price for vertical drain at end bents, per each. No direct payment will be made for excavation, backfilling, compaction, drain pipe or other material and work incidental to the drainage system.

## SECTION 717

### TIMBER CONSTRUCTION

**717.1 Description.** This work shall consist of furnishing and erecting untreated and treated timber, except piling, which remains a permanent part of the structure.

**717.2 Material.**

**717.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Paint	<a href="#">1045.3</a>
Lumber and Timber	<a href="#">1050.3</a>

Fastening devices shall be of good commercial quality.

**717.2.2** Lumber and timber on the site of the work shall be stored in piles. Untreated material shall be open-stacked at least 12 inches (300 mm) above the ground surface and shall be piled to shed water and to prevent warping. Treated timber may be close-stacked and shall be piled to prevent warping. Treated timber shall be carefully handled without dropping, bruising or penetrating the surface with tools. It shall not be dragged across the ground and shall be handled with rope slings, or shall otherwise be properly protected. The contractor will not be permitted to make temporary use of treated timber which is to become a permanent part of the structure.

**717.3 Construction Requirements.**

**717.3.1** All timber shall be framed and secured, as shown on the plans, and shall present a neat appearance when finished. Nails and spikes shall be driven with only sufficient force to set the heads flush with the surface of the wood. Deep hammer marks in the wood surfaces will be cause for the rejection of the damaged timber. All places where the surface of treated material is broken shall be thoroughly coated with two applications of preservative of the same type used in the original treatment. The second coat shall be applied after the first coat has been absorbed.

**717.3.2** Untreated floor planks shall be standard rough sawn, and the openings between adjacent planks shall vary from 1/4 to 1/2 inch (6 to 13 mm) and shall be arranged so that full width planks may be used throughout the structure. Treated floor planks shall be surfaced on four sides (S4S) and laid with edges in full contact. Floor planks shall be laid with heart side down. Each floor plank shall be secured to each nailing strip or joist with a minimum of two steel wire spikes.

**717.3.3** The ends of transverse planking shall be sawed or laid to straight lines from end to end of the bridge. Longitudinal planking shall be laid with staggered joints. The ends of all timber shall be sawed square unless otherwise specified.

**717.3.4** Backing plank for end bents shall be placed so that any irregularities in the piling can be compensated for by varying the thickness of the backing supports to place the surface of the backing in a true plane.

**717.3.5** If bolts with countersunk heads are shown on the plans, cut washers shall be used under the heads. O. G. washers shall be used under heads of other bolts and under nuts of all bolts.

**717.3.6** In general, the length of the nails or spikes shall be not less than twice the thickness of the member being fastened. Holes for round drift bolts, dowels and spikes shall be 1/16 inch (1.5 mm) less in diameter than the bolt or dowel to be used. The diameter of holes for square drift bolts or dowels shall be equal to the least dimension of the bolt or dowel. Holes for machine bolts and rods shall be 1/16 inch (1.5 mm) greater than the diameter of the bolt or rod. Holes for lag screws shall be not larger than the body of the screw at the base of the thread. Holes for countersunk heads or nuts shall not be bored larger than is necessary to admit the washer, and such holes shall be filled with pitch, tar, asphalt or other suitable filler.

**717.3.7 Paint.** If painting of timber work is specified, all surfaces in contact shall be given a heavy coat of paint before being placed together, and the complete work shall be given three coats of white paint for wood, evenly applied.

**717.4 Method of Measurement.** Measurement will be made to the nearest 10 board feet (0.01 m<sup>3</sup>). Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**717.5 Basis of Payment.** The accepted quantities of timber in the permanent structure, complete in place, will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for fastening devices.

## SECTION 718

### TEMPORARY BRIDGE

**718.1 Description.** This work shall consist of furnishing the necessary material and constructing a temporary bridge in accordance with the plans.

**718.2 Material.**

**718.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Lumber and Timber	1050.3
Round Timber Piles	1050.5

**718.2.2** A satisfactory grade of sound native lumber and timber may be substituted for items shown on the plans provided the section modulus of the native material for stringers and 8 x 8-inch (200 x 200 mm) pile caps is at least one-third greater than that of the specified items. Typical permissible substitutions based on plan spacing of stringers are as follows:

ENGLISH	
Plan Size in.	Size for Native Timber in.
2 x 10 stringers	3 x 10 or 4 x 8
3 x 10 stringers	4 x 10 or 6 x 8
3 x 12 stringers	4 x 12 or 6 x 10
3 x 14 stringers	4 x 14 or 6 x 12
4 x 14 stringers	6 x 14 or 8 x 12
4 x 16 stringers	6 x 16 or 8 x 14
8 x 8 pile caps	10 x 10
12 x 12 pile caps	12 x 12
METRIC	
Plan Size mm	Size for Native Timber mm
50 x 250 stringers	75 x 250 or 100 x 200
75 x 250 stringers	100 x 250 or 150 x 200
75 x 300 stringers	100 x 300 or 150 x 250
75 x 350 stringers	100 x 350 or 150 x 300
100 x 350 stringers	150 x 350 or 200 x 300
100 x 400 stringers	150 x 400 or 200 x 350
200 x 200 pile caps	250 x 250
300 x 300 pile caps	300 x 300

If the contractor desires to use stringers of different sizes at different spacing, or if the contractor desires to use steel stringers, plans shall be submitted to the engineer for approval.

### **718.3 Construction Requirements.**

**718.3.1** Temporary bridges and approaches shall be constructed as shown on the plans, at the locations and of such length and elevation as specified by the engineer. Approach fills or excavation and surfacing as may be necessary to prepare the crossing for traffic shall be provided, and the crossing shall be opened to traffic prior to any work which might interfere with the present traffic.

**718.3.2** The contractor shall maintain in good condition all temporary structures, approaches and fills until the permanent structure is opened to traffic. The contractor shall then remove the temporary structure, all refuse and debris, and the approach fills, and shall leave the site in a neat and acceptable condition. After removal, material of the temporary bridge shall become the property of the contractor and shall, before acceptance of the work, be removed from the project.

### **718.4 Method of Measurement.**

**718.4.1** Measurement will be made to the nearest foot (0.5 m) from center to center of end supports.

**718.4.2** All excavation necessary in constructing and removing approach fills as directed will be measured and included for payment with the regular roadway excavation quantities.

### **718.5 Basis of Payment.**

**718.5.1** Accepted temporary bridges, complete in place and subsequent removal, will be paid for at the contract unit price.

**718.5.2** If a temporary bridge is washed out through no negligence or fault of the contractor, the actual cost of replacement by the contractor will be borne by the Commission.

## SECTION 721

### CONCRETE CRIB-TYPE RETAINING WALLS

**721.1 Description.** This work shall consist of constructing closed or open face concrete crib-type retaining walls as specified in the contract in conformity with the dimensions, lines and grades shown on the plans or established by the engineer.

**721.2 Material.**

**721.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Reinforcing Steel for Concrete	1036

**721.2.2** Crib units shall be constructed of Class A-1 concrete. Material, proportioning, air entraining, mixing, slump and transporting portland cement concrete shall be in accordance with [Sec 501](#). Concrete shall be placed and finished in accordance with the applicable provisions of [Sec 703](#).

**721.3 Construction Requirements.**

**721.3.1** Reinforcing steel bars shall be arranged symmetrically about the principal axis of the unit. The area of reinforcement for each unit shall be not less than 0.9 percent of its gross cross-sectional area. All reinforcing bars shall be held accurately in place with ties and chairs.

**721.3.2** Crib units shall conform to the dimensions shown on the plans and shall be so cast that those of the same nominal size will be fully interchangeable. The units shall not be removed from forms and casting beds in less than 12 hours after casting and until a flexural strength of not less than 300 pounds per square inch (2 MPa) or a compressive strength of not less than 1400 pounds per square inch (10 MPa), is attained. The engineer will determine which test, compressive or flexural, will be made. Flexural strength and compressive strength will be determined by tests made in accordance with MoDOT methods. Concrete shall be cured for not less than seven days in accordance with [Sec 703.3.17](#) except membrane curing will not be permitted. The units shall be dense, sound and free from cracks, spalls or surface imperfections.

**721.3.3** Units shall be stored and handled carefully. Damaged members shall be replaced at the contractor's expense. The bottom stretchers shall be placed on firm material. The units shall be erected to the elevations shown on the plans, and when assembled shall present a uniform, skillfully built appearance. The stretchers shall be laid 1/4 inch (6 mm) from the projecting lugs on the headers. One layer of commercially available 50-pound (2666 g/m<sup>2</sup>) roofing felt shall be placed between bearing areas of members.

**721.3.4** Backfilling operations, and filling within the crib, shall closely follow the erection of the successive tiers of units, and the walls shall not be laid higher than 3 feet (1 m) above the backfilled plane. Backfill material and backfilling procedures outside the crib units shall conform to the applicable requirements of [Sec 206.4.9](#). The crib units shall be filled with clay or impervious earth to approximately 6 inches (150 mm) above the finished ground line in front of the wall. The fill material shall be thoroughly tamped and sloped to drain. Closed face crib walls shall be filled above the impervious material with a coarse aggregate

approximating Gradation A, [Sec 1005.1.4](#). Open face crib wall units shall be filled above the impervious material with quarry run stone, consisting of approximately 50-pound (25 kg) stones with sufficient finer material to fill the interstices. A layer of the larger stone shall be carefully placed along the inside face of the units to block the openings between the stretchers and prevent loss of finer material.

**721.4 Method of Measurement.**

**721.4.1** Measurement of concrete crib-type retaining walls will be made to the nearest square foot (0.1 m<sup>2</sup>) of area of the sloping front face of the wall for each width of cell. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**721.4.2** Excavation for construction of crib-type retaining walls will be measured and paid for in accordance with [Sec 206](#).

**721.5 Basis of Payment.** The accepted quantity of concrete crib-type retaining walls, complete in place, will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for furnishing or placing fill or backfill material.



## SECTION 722

### METAL BIN-TYPE RETAINING WALLS

**722.1 Description.** This work shall consist of constructing closed face metal bin-type retaining walls as specified in the contract in conformity with the dimensions, lines and grades shown on the plans, or established by the engineer.

**722.2 Material.**

**722.2.1** All material shall conform to Division 1000, Materials Details.

Item	Section
Sheet Metal	<a href="#">1020</a>

The thickness of the metal will be specified in the contract.

**722.3 Construction Requirements.**

**722.3.1** Excavating of the lower 18 inches (450 mm) of foundation material shall be made carefully in the form of trenches just wide enough to allow the bottom members of the wall to be placed. Foundation beds for the base plates of the columns shall be accurately placed on firm material, shaped to line, grade and slope.

**722.3.2** The units shall be installed as shown on the plans. Proper care shall be taken during handling and installing to avoid damage to the members or spelter coatings. Damaged members may, unless repaired to the satisfaction of the engineer, be rejected at the site. Damage to spelter shall be repaired in accordance with [Sec 712.14](#).

**722.3.3** Backfill material and backfilling procedures inside and outside the bins shall comply with the applicable portions of [Sec 721.3.4](#). The bins may be filled and the wall backfilled as the wall is erected, provided caution is used to hold the columns in correct position while these operations are in progress.

**722.4 Method of Measurement.**

**722.4.1** Measurement of metal bin-type retaining walls will be made to the nearest square foot (0.1 m<sup>2</sup>) of the front face of the wall for each width of bin. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**722.4.2** Excavation for constructing metal bin-type retaining walls will be measured and paid for in accordance with [Sec 206](#).

**722.5 Basis of Payment.** The accepted quantities of metal bin-type retaining walls, complete in place, will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for furnishing or placing fill or backfill material.

## SECTION 725

### METAL PIPE AND PIPE-ARCH CULVERTS

#### 725.1 Description.

**725.1.1** This work shall consist of providing corrugated metal pipe of the diameter or shape designated, laid upon a firm bed and backfilled as specified.

**725.1.2** The contract will specify either the type of pipe or the group of permissible type of pipe. If a group of permissible types is specified, the contractor shall use any of the types listed within the specified group as follows:

##### Group A

- Reinforced Concrete Pipe
- Vitrified Clay Culvert and Sewer Pipe
- Corrugated Metallic-Coated Steel Pipe
- Corrugated Aluminum Alloy Pipe

##### Group B

- Reinforced Concrete Pipe
- Corrugated Metallic-Coated Steel Pipe
- Corrugated Aluminum Alloy Pipe
- Corrugated Polyethylene Pipe

**725.1.3** If the contract specifies corrugated metallic-coated steel pipe culverts of 60-inch (1500 mm) diameter or larger, the contractor may substitute structural plate pipe of like sizes, lengths and thicknesses of steel, constructed in accordance with the requirements of [Sec 727](#). All costs of substituting and installing structural plate pipe shall be considered as completely covered by the contract unit price for the respective corrugated steel pipe.

**725.1.4** If the contract specifies corrugated metallic-coated steel pipe or corrugated aluminum alloy pipe, or if the contract specifies pipe culverts by group number and the contractor elects to furnish corrugated metallic-coated steel pipe or corrugated aluminum alloy pipe, the thickness of metal and size of corrugation for the respective pipe size shall be in accordance with [Table I](#) or [II](#), as applicable, unless otherwise specified. The overfill height shown on the plans or in the contract shall be used to determine the proper sheet thickness and size of corrugation for the individual pipe culvert.

**725.1.5** If the contract specifies pipe culverts by group number, and the contractor elects to furnish vitrified clay or reinforced concrete pipe, the culvert shall be constructed in accordance with [Sec 726](#). If the contractor elects to furnish corrugated polyethylene pipe, the culvert shall be constructed in accordance with [Sec 730](#).

**725.1.6** The thickness of metal or size of corrugation shall not be changed throughout the length of any individual pipe culvert.

**725.1.7** The type of pipe permitted in extending an existing pipe shall, in general, conform to the type used in place, except as otherwise specified in the contract, or unless prohibited by any of the requirements set out herein.

**725.1.8** Corrugated metal pipe-arch shall only be used if specified in the contract or shown on the plans. Allowable overfill heights shown in [Tables I](#) and [II](#) do not apply to pipe-arch.

<b>TABLE I</b>											
<b>Corrugated Metallic-Coated Steel Circular Pipe</b>											
<b>ENGLISH</b>											
<b>Maximum Allowable Overfill Heights (ft)</b>											
<b>Specified Diameter of Pipe (in.)</b>	<b>Minimum Cover (ft)</b>	<b>Specified Thickness of Coated Sheet, in.</b>									
		<b>0.064</b>		<b>0.079</b>		<b>0.109</b>		<b>0.138</b>		<b>0.168</b>	
		<b>A*</b>	<b>B*</b>	<b>A*</b>	<b>B*</b>	<b>A*</b>	<b>B*</b>	<b>A*</b>	<b>B*</b>	<b>A*</b>	<b>B*</b>
12	1	80	....	90	....	....	....	....	....	....	....
15	1	65	....	70	....	....	....	....	....	....	....
18	1	55	....	60	....	....	....	....	....	....	....
21	1	40	....	50	....	60	....	....	....	....	....
24	1	35	....	40	....	45	....	....	....	....	....
30	1	25	....	30	....	35	....	....	....	....	....
36	1	25	40	25	45	25	55	30	70	....	80
42	1	20	30	20	35	25	40	25	50	25	55
48 (Round)	1	20	30	20	30	20	35	25	40	25	45
48**	1	25	35	35	45	45	65	50	80	50	85
54**	1	....	30	30	40	40	55	45	70	45	75
60**	1	....	25	....	35	40	50	40	60	45	65
66**	1	....	25	....	30	30	45	40	55	40	60
72**	1	....	20	....	30	....	40	30	50	40	55
78**	1	....	20	....	25	....	40	....	45	30	50
84**	1	....	20	....	25	....	35	....	45	25	50
90**	1	....	15	....	20	....	35	....	40	....	45
96**	1	....	15	....	20	....	30	....	40	....	40
102**	2	....	15	....	20	....	30	....	35	....	40
108**	2	....	....	....	20	....	25	....	35	....	35
114**	2	....	....	....	15	....	25	....	30	....	35
120**	2	....	....	....	....	....	20	....	30	....	35

\* A=2 2/3 by 1/2-inch corrugations      B=3 by 1-inch corrugations.

\*\*Shop elongated in accordance with [Sec 725.5](#).

METRIC											
Maximum Allowable Overfill Heights (m)											
Specified Diameter of Pipe (mm)	Minimum Cover (mm)	Specified Thickness of Coated Sheet, mm									
		1.6		2.0		2.8		3.5		4.3	
		A*	B*	A*	B*	A*	B*	A*	B*	A*	B*
300	300	24	....	27	....	....	....	....	....	....	....
375	300	20	....	21	....	....	....	....	....	....	....
450	300	17	....	18	....	....	....	....	....	....	....
525	300	12	....	15	....	18	....	....	....	....	....
600	300	11	....	12	....	14	....	....	....	....	....
750	300	8	....	9	....	11	....	....	....	....	....
900	300	8	12	8	14	8	17	9	21	....	24
1050	300	6	9	6	11	8	12	8	15	8	17
1200 (Round)	300	6	9	6	9	6	11	8	12	8	14
1200**	300	8	11	11	14	14	20	15	24	15	26
1350**	300	....	9	9	12	12	17	14	21	14	23
1500**	300	....	8	....	11	12	15	12	18	14	20
1650**	300	....	8	....	9	9	14	12	17	12	18
1800**	300	....	6	....	9	....	12	9	15	12	17
1950**	300	....	6	....	8	....	12	....	14	9	15
2100**	300	....	6	....	8	....	11	....	14	8	15
2250**	300	....	5	....	6	....	11	....	12	....	14
2400**	300	....	5	....	6	....	9	....	12	....	12
2550**	600	....	5	....	6	....	9	....	11	....	12
2700**	600	....	....	....	6	....	8	....	11	....	11
2900**	600	....	....	....	5	....	8	....	9	....	11
3000**	600	....	....	....	....	....	6	....	9	....	11

\* A=68 x 13 mm corrugations      B=76 x 25 mm corrugations.

\*\*Shop elongated in accordance with [Sec 725.5](#).

TABLE II				
Corrugated Aluminum Alloy Circular Pipe				
ENGLISH				
2 2/3 by 1/2 in. Corrugations				
Allowable Overfill Heights (ft)				
Specified Diameter of Pipe (in.)	Specified Sheet Thickness, in.			
	0.075	0.105	0.135	0.164
12	1-37	....	....	....
15	1-33	34-38	....	....
18	1-19	30-35	....	....
21	1-25	26-30	31-35	....
24	....	1-29	30-33	....
30	....	1-23	24-28	29-30
36	....	....	1-22	23-27
42	....	....	1-17	18-24
48 (Round)	....	....	1-11	12-17
METRIC				
68 x 13 mm Corrugations				
Allowable Overfill Heights (m)				
Specified Diameter of Pipe (mm)	Specified Sheet Thickness, mm			
	1.9	2.7	3.4	4.2
300	0.3-11	....	....	....
375	0.3-10	10-12	....	....
450	0.3-6	9-11	....	....
525	0.3-8	8-9	9-11	....
600	....	0.3-9	9-10	....
750	....	0.3-7	7-9	9
900	....	....	0.3-7	7-8
1050	....	....	0.3-5	6-7
1200 (Round)	....	....	0.3-3	4-5

## 725.2 Material.

**725.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Corrugated Metallic-Coated Steel Culvert Pipe, Pipe-Arches and End Sections	<a href="#">1020</a>
Corrugated Aluminum Alloy Culvert Pipe	<a href="#">1024</a>

## Construction Requirements

**725.3 Excavation.** If the pipe is to be laid below the ground line, the trench shall be excavated to the required depth. The bottom of the trench shall be shaped to conform to the bottom of the pipe for at least 10 percent of its overall height and shall afford a uniformly firm bed throughout its entire length. In lieu of shaping the trench, the pipe may be placed on a 2-inch (50 mm) thick bed of sand and backfilled in accordance with the requirements of [Sec 725.6.1](#). If rock is encountered, the trench shall be excavated 6 inches (150 mm) below the bottom of the pipe, and backfilled with suitable material thoroughly compacted and shaped. Soft or yielding material shall be removed and replaced with suitable material tamped thoroughly into place. If the pipe is not laid in a trench, a uniformly firm bed shall be provided.

### 725.4 Laying Pipe.

**725.4.1** The pipe shall be carefully laid true to lines and grades shown on the plans, with the outside laps of circumferential joints pointing upstream and with longitudinal laps on the sides. If pipe sections are joined on the work, the ends shall be butted as closely as the corrugations will permit and shall be joined with a firmly bolted coupling band of the same material as the pipe. Multiple culverts, unless shown otherwise on the plans, shall be laid with 1/2 span of the pipe, or a minimum of one foot (300 mm), whichever is the greater, between the culverts. Any pipe which is not in true alignment or which shows any undue settlement after laying shall be taken up and relaid at the contractor's expense. If shown on the plans, or directed by the engineer, camber shall be built into the pipe structure to compensate for settlement from fill loads.

**725.4.2** Proper care shall be taken during handling and installation to avoid damage to metallic coating or cladding. Pipe on which such coatings have been damaged may, unless repaired to the satisfaction of the engineer, be rejected at the site of the work regardless of previous approvals.

**725.4.3** Pipe having any localized bends in excess of 5 percent of the specified pipe diameter, or any dent in excess of 1/2 inch (13 mm), will be rejected. Pipe rejected because of these defects may be used if satisfactorily repaired. Repair may be made by jacking or by any other method meeting the approval of the engineer.

**725.5 Shop Elongation.** Round corrugated steel pipe of 54 inches (1350 mm) or over in diameter shall be shop elongated. Corrugated metallic-coated steel pipe 48 inches (1200 mm) in diameter may be furnished round or shop elongated in accordance with [Table I](#). The contractor shall be responsible for maintaining elongation during backfilling and embankment construction such that the vertical height of the opening after the embankment has been completed shall be not less than the diameter of the pipe, nor greater than the pre-elongated height.

**725.6 Backfilling.** Suitable backfill and embankment material, free from large lumps, clods or rocks, shall be placed alongside the pipe in loose layers not exceeding 6 inches (150 mm) thick to provide a berm of compacted earth, on each side of the pipe, at least as wide as the diameter of the pipe. Each 6-inch (150 mm) layer shall be thoroughly compacted to the same density required for the adjacent embankment. Backfill material shall be moistened, if necessary, to facilitate compaction. Where shop elongated pipe is used, special care will be required in bringing backfill material up uniformly on both sides of the pipe simultaneously. Filling and compacting shall be continued until the embankment is level with the top of the

pipe if the top of the pipe is above the original surface, otherwise it shall be continued until the embankment is level with the original surface.

**725.6.1** Pipe laid on a sand bed shall be backfilled with sand for at least 10 percent of its overall height. The sand shall be thoroughly compacted by the use of tampers or by flooding. The remainder of the backfill shall be in accordance with the requirements of [Sec 725.6](#).

**725.7 Beveled End Section.** The plans will indicate those corrugated steel pipe culverts which are to have beveled end sections and the slope of the cutting line. The required slope on opposite ends of any individual structure will be identical in order that the portion of pipe cut off in forming the required beveled end section on one end of the structure can be used on the opposite end of the structure. On skewed round structures with beveled end sections, the end sections shall be rotated as required to better fit the adjacent roadway slope. Shop elongation will be required in accordance with [Sec 725.5](#).

**725.8 Corrugated Metal Drop Inlets.** The contractor shall install corrugated metal drop inlets of the proper size and length at the locations shown on the plans. The drop inlet shall be constructed of the same base metal and thickness of corrugated metal as used in the culvert pipe and shall meet the requirements of [Sec 1020](#) or [1024](#), as applicable.

**725.9 Corrugated Metal Curtain Walls.** The contractor shall install metal curtain walls of the proper size and shape at locations shown on the plans. The metal curtain walls shall be constructed of the same base metal used in the culvert pipe, shall be of the thickness of metal shown on the plans, and shall meet the requirements of [Sec 1020](#) or [1024](#), as applicable.

**725.10 Method of Measurement.**

**725.10.1** Measurement of corrugated metal pipe or pipe-arch, complete in place, will be made to the nearest foot (0.5 m) along the geometrical center of the pipe. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**725.10.2** Excavation for placing pipe, pipe-arches, corrugated metal drop inlets and metal curtain walls will be measured and paid for as Class 3 Excavation in accordance with [Sec 206](#).

**725.11 Basis of Payment.**

**725.11.1** The accepted quantities of pipe, complete in place, including all necessary tees, bends, wyes, coupling bands, cutting and joining new pipe to existing pipe or structures unless otherwise specified, will be paid for at the unit price for each of the pay items included in the contract.

**725.11.2** No direct payment will be made for beveling, skewing, nor for any additional work required in laying pipe with beveled or skewed ends, nor work involved in elongating, nor for any backfilling required except as specified in [Sec 206.6.3](#).

**725.11.3** The accepted quantities of corrugated metal drop inlets, and metal curtain walls, complete in place, including coupling bands, toeplates, nuts and bolts will be paid for at the unit price for each of the pay items included in the contract.

## SECTION 726

### RIGID PIPE CULVERTS, STORM DRAINS AND SEWERS

#### 726.1 Description.

**726.1.1** This work shall consist of concrete and vitrified clay pipe of the diameter or shape designated, laid upon a firm bed and backfilled as specified.

**726.1.2** The contract will specify either the type of pipe or the group of permissible types of pipe. If a group of permissible types is specified, the contractor shall use any one of the types listed within the specified group as follows:

##### Group A

Reinforced Concrete Pipe  
Vitrified Clay Culvert and Sewer Pipe  
Corrugated Metallic-Coated Steel Pipe  
Corrugated Aluminum Alloy Pipe

##### Group B

Reinforced Concrete Pipe  
Corrugated Metallic-Coated Steel Pipe  
Corrugated Aluminum Alloy Pipe  
Corrugated Polyethylene Pipe

**726.1.3** If the contract specifies reinforced concrete pipe, or if the contract specifies pipe culverts by group number, and the contractor elects to furnish reinforced concrete pipe, the class of bedding and the class of pipe shall conform to the requirements of [Table I](#) for the applicable allowable overfill height.

<b>TABLE I</b>				
<b>Reinforced Concrete Pipe</b>				
<b>ENGLISH</b>				
<b>Allowable Overfill Heights (ft)</b>				
<b>Class of Pipe</b>	<b>Bedding Class</b>			
	<b>C</b>	<b>B</b>	<b>B1</b>	<b>A*</b>
III	1-15	16-18	34-42	....
IV	1-22	23-27	43-65	100
V	1-27	28-33	65-80	124
<b>METRIC</b>				
<b>Allowable Overfill Heights (m)</b>				
<b>Class of Pipe</b>	<b>Bedding Class</b>			
	<b>C</b>	<b>B</b>	<b>B1</b>	<b>A*</b>
III	0.3-5	5-6	10-13	....
IV	0.3-7	7-8	13-20	30
V	0.3-8	9-10	20-24	38

\*With imperfect trench.

**726.1.4** If the contract specifies vitrified clay pipe, or if the contract specifies pipe culverts by group number and the contractor elects to furnish vitrified clay pipe, such pipe shall be placed



in a trench conforming to the requirements of Table II for the applicable allowable overfill height.

<b>TABLE II</b>		
<b>Vitrified Clay Pipe (Extra Strength)</b>		
<b>Nominal Diameter of Pipe</b>	<b>Trench Width at 1 ft (300 mm) Above Top of Pipe (Max)</b>	<b>Allowable Overfill Height</b>
<b>in. (mm)</b>	<b>ft (m)</b>	<b>ft (m)</b>
8 (200)	2.5 (0.8)	4-12 (1.2-3.7)
10 (250)	2.5 (0.8)	4-12 (1.2-3.7)
12 (300)	3.0 (0.9)	4-13 (1.2-4.0)
15 (375)	3.0 (0.9)	4-17 (1.2-5.2)
18 (450)	3.5 (1.1)	4-17 (1.2-5.2)
21 (525)	4.0 (1.2)	4-17 (1.2-5.2)
24 (600)	4.0 (1.2)	3-19 (.09-5.8)
30 (750)	4.5 (1.4)	3-19 (.09-5.8)
36 (900)	5.0 (1.5)	3-19 (.09-5.8)
<b>Vitrified Clay Pipe (Standard Strength) (Not permitted under vehicular traffic)</b>		
<b>Nominal Diameter of Pipe</b>	<b>Trench Width at 1 ft (300 mm) Above Top of Pipe (Max)</b>	<b>Allowable Overfill Height</b>
<b>in. (mm)</b>	<b>ft (m)</b>	<b>ft (m)</b>
6 (150)	2.0 (0.6)	1-9 (0.3-2.7)
8 (200)	2.0 (0.6)	1-7 (0.3-2.1)
10 (250)	2.5 (0.8)	1-7 (0.3-2.1)
12 (300)	2.7 (0.8)	1-6 (0.3-1.8)
15 (375)	3.5 (1.1)	1-6 (0.3-1.8)
18 (450)	3.5 (1.1)	1-6 (0.3-1.8)
21 (525)	4.0 (1.2)	1-6 (0.3-1.8)
24 (600)	4.0 (1.2)	1-8 (0.3-2.4)
30 (750)	4.5 (1.4)	1-10 (0.3-3.0)
36 (900)	5.0 (1.5)	1-11 (0.3-3.4)

**726.1.5** If the contract specifies pipe culverts by group number, and the contractor elects to furnish metal pipe, the culvert shall be constructed in accordance with [Sec 725](#). If the contractor elects to furnish corrugated polyethylene pipe, the culvert shall be constructed in accordance with [Sec 730](#).

**726.1.6** If the contract specifies non-reinforced concrete pipe, the contractor may, at no additional cost to the Commission, furnish reinforced concrete pipe of like sizes meeting the requirements of these specifications.

**726.1.7** If reinforced concrete pipe is specified in the contract or elected for use by the contractor, pipe of a higher class may be used but payment will be made for the class of pipe specified in the contract for that culvert.

**726.1.8** The type of pipe or class of bedding shall not be changed throughout the length of any individual pipe culvert.

**726.1.9** The type of pipe permitted in extending an existing pipe shall, in general, conform to the type used in place, except as otherwise specified in the contract, or unless prohibited by any of the requirements set out herein.

**726.1.10** If standard strength vitrified clay pipe is specified in the contract or elected for use by the contractor, extra strength vitrified clay pipe may be used but payment will be made for standard strength vitrified clay pipe. Only extra strength vitrified clay pipe shall be used under roadways. Standard strength vitrified clay pipe will be permitted only where vehicular traffic is not anticipated.

## **726.2 Material.**

**726.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

<b>Item</b>	<b>Section</b>
Reinforced Concrete Culvert, Storm Drain and Sewer Pipe	<a href="#">1026</a>
Vitrified Clay Sewer and Culvert Pipe	<a href="#">1030</a>
Reinforced Concrete Elliptical Culvert, Storm Drain and Sewer Pipe	<a href="#">1034</a>
Reinforced Concrete Arch Culvert, Storm Drain and Sewer Pipe	<a href="#">1035</a>
Plastic Joint Compound for Vitrified Clay and Concrete Pipe	<a href="#">1057.3</a>
Tubular Joint Seal	<a href="#">1057.4</a>
Mortar for Pipe Joints	<a href="#">1066</a>

## **Construction Requirements**

## **726.3 Laying.**

**726.3.1** Rigid pipe shall be carefully laid true to lines and grades shown on the plans, with hub, bell or groove ends upstream and with the spigot or tongue end entered the full length into the adjacent section of pipe. Elliptically reinforced pipe shall be oriented and laid such that the top and bottom of the pipe, as marked on the pipe, are in the proper position. If the pipe is to be laid below the ground line, a trench shall be excavated to the required depth and of a width sufficient to permit thorough tamping of the backfill under the haunches and around the pipe. Any pipe which is not in true alignment or which shows any undue settlement after laying, but before the fill is placed, shall be taken up and relaid at the contractor's expense. If shown on the plans, or directed by the engineer, sufficient camber shall be built into the pipe structure to allow for settlement from fill loads. All joints, except for field or private entrance culverts, shall be sealed with an approved plastic compound, cement mortar or tubular joint seal. Rubber gasketed joints may be used at no additional cost to the Commission. Where permissible lift holes have been used, the holes shall be carefully filled with expansive mortar to provide a watertight section. The mortar shall be finished flush on the inside of the pipe and shall be properly cured on the outside. Lifting devices shall have sufficient bearing on the inside of the pipe to avoid damage resulting from a concentration of stresses around the lift holes.

**726.3.2** If rubber gasket type pipe or vitrified clay pipe is specified or used, the joints shall be installed in accordance with the manufacturer's recommendations to ensure that joint devices are properly installed and that rubber gaskets are not displaced.

**726.3.3** In sealing rigid pipe with mortar, the mortar contact areas of all pipe ends shall be damp when mortar is applied. After applying mortar to the entire interior surface of the bell or groove, the spigot or tongue end shall be forced into position. Any remaining void in the bell or groove shall be filled with a hub of mortar built up adjacent to the bell, or a bead of mortar built up around a groove-type joint. The interior joints of either type of pipe shall be finished flush with the surface of the pipe. Outside surface of mortar joints shall be cured with membrane curing compound.

**726.3.4** In sealing rigid pipe with plastic joint compound, trowel grade compound shall be applied to the mating surfaces of both the tongue and groove, or to the entire interior surface of the bell and the upper portion of the spigot. Rope or tape type plastic compound shall be applied in accordance with the manufacturer's recommendations. The joints shall be forced together with excess compound extruding both inside and outside the joint. Excess compound shall be removed from the interior surface where accessible. Tubular joint seals shall be installed in a manner as recommended by the manufacturer. The joint between the bell and spigot shall be uniform for the full circumference and care shall be taken to prevent the bell from supporting the spigot.

#### **726.4 Bedding.**

**726.4.1** Bedding for reinforced concrete pipe will be classified as Class A, Class B, Class B1, or Class C. If reinforced concrete pipe is specified, it shall be laid with Class C bedding unless otherwise specified on the plans.

**726.4.1.1** Class A bedding shall be used if, in the judgment of the engineer, soil conditions are such that a firm bed cannot be otherwise secured. The pipe shall be laid in the center of a concrete cradle having a minimum width of 6 inches (150 mm) greater than the outside diameter of the pipe. The minimum thickness of the cradle under the bottom of the pipe shall be 1/4 of the internal diameter of the pipe, and the cradle shall extend up the sides of the pipe for a height equal to 1/4 its outside diameter. The concrete shall be Class B, or concrete of a commercial mixture meeting the requirements of [Sec 501.14](#).

**726.4.1.2** Class B bedding shall consist of a soil foundation covered with a 2-inch (50 mm) layer of sand shaped to fit the lower part of the pipe exterior for at least 10 percent of its overall height. The sand shall be omitted for a distance of 20 feet (6 m) at the upstream end when the pipe is to be used as a crossroad culvert.

**726.4.1.3** Class B1 bedding (Imperfect Trench) shall consist of a foundation constructed in accordance with the requirements for Class B bedding. The pipe shall be laid by either of the following methods:

(a) Installation of Pipe Prior to Placing Embankment. After the pipe has been laid, and backfilled in accordance with [Sec 726.6](#), the embankment shall be placed and compacted to the required density for a lateral distance each side of the pipe of at least five times the outside diameter and to an elevation above the top of the pipe equal to the outside diameter of the pipe plus one foot (300 mm). A trench, one outside pipe diameter wide, directly over the pipe, shall be dug through the compacted embankment to an elevation one foot (300 mm) above the top of the pipe. The trench walls shall be as nearly vertical as practicable. The trench shall be backfilled with loose dry material placed in the loosest condition practicable. Straw, hay, leaves or sawdust may be used to fill the lower 1/4 to 1/3 of the trench.

(b) Installation of Pipe After Placing Embankment. The roadway embankment shall be placed and compacted to the required density for a distance of at least five outside pipe diameters each side of the pipe and to a height of one outside diameter above the

proposed top of the pipe. A trench, having a width of one outside pipe diameter plus 8 inches (200 mm) each side, shall be excavated through the embankment. The trench walls shall be as nearly vertical as practicable. After laying the pipe, the trench shall be backfilled with sand in layers not exceeding 6 inches (150 mm) thick to the top of the pipe. Each layer shall be thoroughly compacted by the use of tampers or by flooding. The remainder of the trench shall be backfilled as in (a) above.

**726.4.1.4** Class C bedding shall consist of a soil foundation shaped to fit the lower part of the pipe exterior for at least 10 percent of its overall height, and shall afford a uniformly firm bed throughout its entire length. In lieu of Class C bedding, Class B bedding may be used at no additional cost to the Commission.

**726.4.2** Vitrified clay pipe (extra strength) shall be laid in a trench with a width, on a plane level with the top of the pipe, not greater than that shown in [Table II](#) for the respective pipe diameter. The trench shall have a minimum depth of one outside pipe diameter plus 16 inches (400 mm). If the original ground line is below an elevation one foot (300 mm) above the top of the proposed pipe, embankment shall be constructed to at least one foot (300 mm) above the proposed pipe prior to excavating the trench. The trench walls shall be as nearly vertical as practicable. Prior to laying the pipe, the bottom of the trench shall be covered with a 4-inch (100 mm) layer of sand. After laying the pipe, the trench shall be backfilled with sand around the pipe for at least 10 percent of the height of the pipe. The sand shall be thoroughly compacted by the use of tampers or by flooding. The remainder of the trench shall be backfilled in accordance with the requirements of [Sec 726.6.1](#).

**726.4.3 Bedding in Unsuitable Material.** If rock is encountered, an earth cushion having a thickness of not less than 1/2 inch per foot (42 mm/m) height of fill over the top of the pipe, with a minimum allowable thickness of 6 inches (150 mm) and a maximum thickness not to exceed 3/4 the inside diameter of the pipe, shall be constructed under the pipe. The pipe shall then be bedded as applicable. The width of the cushion excavation shall be one foot (300 mm) greater than the outside diameter of the pipe and the trench shall be backfilled with suitable material to provide a uniformly firm bed. If soft, spongy, or unstable material is encountered it shall be removed from the bedding and the space backfilled with suitable material to provide a uniformly firm bed. Payment for removal of unsuitable material and for backfilling will be made in accordance with [Sec 206.6.3](#), unless the unsuitable material is a result of the contractor's operations in which case the removing and backfilling shall be at the contractor's expense.

**726.5 Pipe Plugs.** The ends of all pipe stubs for future connections at inlet and manhole structures and of all pipe installed as a portion of future sewers shall be sealed with suitable plugs. The plugs shall be installed in a manner preventing infiltration of dirt into the pipe. No direct payment will be made for furnishing and installing plugs.

## **726.6 Backfilling.**

**726.6.1** Backfilling shall be done as soon as practicable. Suitable backfill and embankment material, free from large lumps, clods or rocks, shall be placed alongside the pipe in loose layers not exceeding 6 inches (150 mm) thick to provide a berm of compacted or undisturbed earth, on each side of the pipe, at least as wide as the external diameter of the pipe. Each 6-inch (150 mm) layer shall be thoroughly compacted to the same density required for the adjacent embankment. Backfill material shall be moistened, if necessary, to facilitate compaction. Special care shall be taken to compact the embankment thoroughly under the haunches of the pipe. Filling and compacting shall be continued until the embankment is level with the top of the pipe if the top of the pipe is above the original surface, otherwise it shall be continued until the embankment is level with the original surface. Before heavy construction

equipment is operated over the pipe, the contractor shall provide an adequate depth and width of compacted backfill to protect it from damage or displacement. Any damage or displacement shall be repaired or corrected at the contractor's expense.

**726.6.2 Pipe in Trenches of 15 Feet (4.5 m) or Less in Depth Above the Top of the Pipe.**

At the contractor's option, pipe in trenches of 15 feet (4.5 m) or less in depth may be backfilled as follows in lieu of the method described in [Sec 726.6.1](#). The trench shall be backfilled with sand placed in layers not exceeding 6 inches (150 mm) thick to a height of 12 inches (300 mm) over the pipe. Each layer shall be compacted by the use of tampers to not less than 90 percent of standard maximum density. Special care shall be taken to compact the sand under the haunches of the pipe. The trench above the level of 12 inches (300 mm) over the pipe shall be backfilled and compacted in accordance with the requirements for backfilling as specified in [Sec 726.6.1](#), except that the material for backfilling may consist of crushed stone, pit run gravel, broken cement mortar, broken brick, sand, moulders sand, or similar type material, provided that such material is of a gradation that will form a dense mass when compacted. The final 2 feet (600 mm) of backfill shall consist of suitable earth material. Backfilling around manholes and drop inlets may be performed in a like manner.

**726.6.3 Pipe in Trenches Over 15 Feet (4.5 m) in Depth Above the Top of the Pipe.**

The trench shall be backfilled with sand to a height of 12 inches (300 mm) over the top of the pipe. The sand shall be placed and compacted in layers in accordance with the requirements of [Sec 726.6.2](#). The trench above the portion backfilled with sand shall be backfilled with loose dry material placed in the loosest condition practicable to a minimum height of 18 inches (450 mm) or to a height equal to the outside diameter of the pipe, whichever is greater. The remaining depth of the trench shall be backfilled with suitable material placed in 6-inch (150 mm) layers and compacted in accordance with the requirements of [Sec 726.6.1](#).

**726.7 Inspection.** After the roadway has been completed, and before final acceptance of the project, all pipe culverts will be inspected. Any separation at joints sealed with either cement mortar or plastic joint compound shall be resealed with like material.

**726.8 Method of Measurement.**

**726.8.1** Measurement of rigid pipe, complete in place, will be made to the nearest foot (0.5 m) along the geometrical center of the pipe. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity. The length of structure may be increased by not more than 3 feet (1 m) as necessary to avoid cutting the pipe, but such increased length will not be included in the contract quantity for payment.

**726.8.2** Excavation for placing rigid pipe culverts will be measured and paid for as Class 3 Excavation in accordance with [Sec 206](#), except as follows:

(a) If vitrified clay pipe is specified in the contract or elected for use by the contractor, no direct payment will be made for additional excavation required to cut the trench in the embankment above the original ground line. Class 3 Excavation, below a level line one foot (300 mm) above the top of the pipe will be measured to the nearest cubic yard (cubic meter) of that volume actually removed within an area bounded by the vertical planes of the maximum permissible trench width shown in [Table II, Sec 726](#), for the respective pipe diameter.

(b) If the contractor elects to use reinforced concrete pipe for locations having overfill heights of 34 feet (10 m) or more, no direct payment will be made either for the

excavation required for Class B1 bedding or concrete cradle, or for the concrete for the cradle of Class A bedding.

**726.9 Basis of Payment.**

**726.9.1** The accepted quantities of pipe, complete in place, including all necessary tees, bends, wyes, cutting and joining new pipe to existing pipe unless otherwise specified will be paid for at the unit price for each of the pay items included in the contract. The accepted quantities of pipe by groups will be paid for in accordance with the item numbers, pay items and pay units listed in [Sec 725](#).

**726.9.2** Payment for Class A bedding, complete in place, will be made as Class B concrete regardless of the class of concrete used and will be considered as completely covered by the contract unit price per cubic yard (cubic meter).

**726.9.3** No direct payment will be made for any backfilling required except as specified in [Sec 206.6.3](#).

**726.9.4** No direct payment will be made for the construction of bedding or for bedding material except as provided in [Sec 726.9.2](#).

## SECTION 727

### STRUCTURAL PLATE PIPE AND STRUCTURAL PLATE PIPE-ARCH CULVERTS

**727.1 Description.** This work shall consist of furnishing and installing built-up structural plate round pipe, or built-up structural plate pipe-arch with full metal bottom, of curved sections of galvanized corrugated metal plate bolted together in the field to form the required shape shown on the plans. The thickness of the structural plate will be specified in the contract.

**727.2 Material.**

**727.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Structural Plate Pipe and Pipe-Arches	<a href="#">1023</a>
Corrugated Aluminum Alloy Structural Plate	<a href="#">1024</a>

The size and shape of the plates shall be such that the finished structure will have the dimensions shown on the plans.

#### Construction Requirements

**727.3 Excavation.** The bed for structural plate pipe and pipe-arch culverts shall be formed in accordance with the requirements of [Sec 725.3](#), except that if rock is encountered the trench shall be excavated to a minimum depth of 8 inches (200 mm) below the bottom of the pipe.

**727.4 Laying Pipe.**

**727.4.1** The bottom plates shall be bedded on a firmly tamped foundation of soil or sand of uniform density carefully shaped by means of a template supported at the desired grade to fit the lower plates of the pipe.

**727.4.2** The structure shall be carefully laid true to lines and grades. Any structure which is not in true alignment or which shows undue settlement shall be taken up and relaid at the contractor's expense. If shown on the plans or directed by the engineer, camber shall be built into the structure to compensate for settlement from embankment loads.

**727.4.3** Proper care shall be taken during handling and installation to avoid damage to the coating. Pipe on which such coatings have been damaged may, unless repaired to the satisfaction of the engineer, be rejected at the site of the work regardless of previous approvals.

**727.5 Shop Elongation.** The contractor shall be responsible for maintaining elongation during backfilling and embankment construction such that the vertical height of the opening after the embankment has been completed shall be not less than the diameter of the pipe, nor greater than the pre-elongated height. Steel structural plate round pipe shall be shop elongated. Aluminum structural plate round pipe shop elongation, if required, shall be as shown on the plans. Pipe arches shall not be elongated.

## **727.6 Backfilling.**

**727.6.1** Except where the backfill or embankment is to be formed of stone or rock fill, the material shall be placed in accordance with [Sec 725.6](#). Layers of backfill or embankment shall be kept at approximately the same elevation on opposite sides of the structure at all times during the progress of the work in order to equalize the loading. This method of filling and compacting shall be continued until the top of the embankment is at an elevation level with the top of the structure.

**727.6.2** If the backfill or embankment over and around the structural plate pipe or pipe-arch is specified to be formed of stone or rock fill, a protective inner layer of fine rock particles, preferably mixed with earthy material, tamped into place in contact with the structure, and surrounded by a carefully placed outer layer of rock, shall be built up as the work proceeds around the perimeter of the structure above a specially prepared foundation. The protective layer shall be placed during the progress of the backfilling and placing of the embankment or rock fill in a manner and of sufficient thickness to protect the surface of the structure from injury to the coating. Indiscriminate dumping of rock near the structure before the required protective measures have been completed will not be permitted.

**727.7 Beveled End Sections.** The plans will indicate where beveled end sections are required and the slope of the cutting line. The required slope on opposite ends of any individual structure will be identical in order that the portion of pipe cut off in forming the required beveled end section on one end of the structure can be used on the opposite end of the structure. On skewed round structures with beveled end sections, the end sections shall be rotated as required to better fit the adjacent roadway slope. Shop elongation will be required in accordance with [Sec 727.5](#).

## **727.8 Method of Measurement.**

**727.8.1** Measurement of structural plate pipe, complete in place, will be made to the nearest foot (0.5 m) along the geometrical center of the structure.

**727.8.2** Measurement of structural plate pipe-arch, complete in place, will be made to the nearest foot (0.5 m) along the center of the vertical dimension of the structure.

**727.8.3** Excavation for placing structural plate pipe and pipe-arches will be measured and paid for as Class 3 Excavation in accordance with [Sec 206](#).

## **727.9 Basis of Payment.**

**727.9.1** The accepted quantities of structural plate pipe or structural plate pipe-arch culverts, complete in place, will be paid for at the unit price for each of the pay items included in the contract.

**727.9.2** No direct payment will be made for beveling, skewing, nor for any additional work required in laying structural plate structures with beveled or skewed ends, nor work involved in elongating, nor for any backfilling required except as specified in [Sec 206.6.3](#).



## **SECTION 728**

### **RELAID PIPE**

**728.1 Description.** This work shall consist of removing existing pipe or pipe-arch culverts and cleaning and relaying suitable sections.

**728.2 Construction Requirements.** All work done in relaying pipe or pipe-arch culverts shall be performed in accordance with the requirements for placing new pipe. Pipe may be relaid at the same location or at a new location as shown on the plans or as specified by the engineer. Pipe shall be carefully removed and any cutting that may be required to obtain necessary lengths for relaying shall be done by the contractor.

#### **728.3 Method of Measurement.**

**728.3.1** Measurement will be made to the nearest linear foot (0.5 m) along the geometrical center of the relaid pipe.

**728.3.2** Measurement of Class 3 Excavation for relaying the pipe will be made in accordance with [Sec 206](#).

#### **728.4 Basis of Payment.**

**728.4.1** The accepted quantities of relaid pipe or pipe-arch culvert actually relaid, regardless of size, will be paid for at the contract unit price. No direct payment will be made for excavation for removing the pipe, hauling, cleaning, cutting, joining, furnishing new coupling bands required, backfilling, or disposing of old pipe not relaid.

**728.4.2** Payment for Class 3 Excavation for relaying the pipe will be made at the contract unit price per cubic yard (cubic meter) under roadway items.

## SECTION 729

### PLACING STATE-OWNED PIPE

**729.1 Description.** This work shall consist of laying State-owned pipe or pipe-arch culverts at locations directed by the engineer.

**729.2 Construction Requirements.** State-owned pipe shall be laid in accordance with the requirements for placing new pipe, except that the pipe and all necessary coupling bands will be furnished at the job site by the Commission at no cost to the contractor. Excavation for removal of the pipe will not be required.

**729.3 Method of Measurement.**

**729.3.1** Measurement of placing State-owned pipe will be made to the nearest linear foot (0.5 m) along the geometrical center of the pipe in place.

**729.3.2** Measurement of Class 3 Excavation for placing the pipe will be made in accordance with [Sec 206](#).

**729.4 Basis of Payment.**

**729.4.1** Payment for placing State-owned pipe will be made at the fixed unit price per linear foot of \$5.00 for a 12-inch (per meter of \$16.40 for a 300 mm) diameter pipe plus \$1.00 for each 3-inch (\$3.30 for each 75 mm) additional diameter. Payment for placing pipe-arch will be at the rate for circular pipe from which the arch was developed.

**729.4.2** Payment for Class 3 Excavation for placing the pipe will be made at the contract unit price per cubic yard (cubic meter) under roadway items.

**729.4.3** No direct payment will be made for any required hauling, cutting, joining or backfilling of the pipe.

## SECTION 730

### POLYETHYLENE PIPE CULVERTS

#### 730.1 Description.

**730.1.1** This work shall consist of providing polyethylene pipe of the diameter designated, laid upon a firm bed and backfilled as specified.

**730.1.2** The contract will specify either the type of pipe or the group of permissible types of pipe. If a group of permissible types is specified, the contractor shall use any of the types listed within the specified group as follows:

##### Group A

- Reinforced Concrete Pipe
- Vitrified Clay Culvert and Sewer Pipe
- Corrugated Metallic-Coated Steel Pipe
- Corrugated Aluminum Alloy Pipe

##### Group B

- Reinforced Concrete Pipe
- Corrugated Metallic-Coated Steel Pipe
- Corrugated Aluminum Alloy Pipe
- Corrugated Polyethylene Pipe

**730.1.3** If the contract specifies corrugated polyethylene pipe, or if the contract specifies pipe culverts by group number and the contractor elects to furnish corrugated polyethylene pipe, the allowable overfill height shall be in accordance with Table I, unless otherwise specified. Overfill height will be measured from the top of the pipe.

**730.1.4** If the contract specifies pipe culverts by group number and the contractor elects to furnish metal pipe, the culvert shall be constructed in accordance with [Sec 725](#). If the contractor elects to furnish concrete or vitrified clay pipe, the culvert shall be constructed in accordance with [Sec 726](#).

**730.1.5** The size and shape of corrugation and thickness of wall shall not be changed throughout the length of any individual pipe culvert.

**730.1.6** The type of pipe permitted in extending an existing pipe shall, in general, conform to the type used in place, except as otherwise specified in the contract, or unless prohibited by any of the requirements set out herein.

TABLE I Corrugated Polyethylene Circular Pipe		
Specified Diameter of Pipe	Minimum Overfill Height	Maximum Overfill Height
in. (mm)	ft (m)	ft (m)
12 (300)	1 (0.3)	10 (3.0)
15 (375)	1 (0.3)	12 (3.7)
18 (450)	1 (0.3)	13 (4.0)
24 (600)	1 (0.3)	13 (4.0)
30 (750)	1 (0.3)	12 (3.7)

### 730.2 Material.

730.2.1 All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Metallic-Coated Steel End Sections	<a href="#">1020</a>
Precast Concrete Flared End Sections	<a href="#">1032</a>
Corrugated Polyethylene Culvert Pipe	<a href="#">1047</a>

### Construction Requirements

**730.3 Excavation.** For trench installations, the trench wall shall be at least 18 inches (450 mm) from either side of the pipe. For embankment installations, the backfill material shall be a minimum width of one pipe diameter on both sides of the pipe. A minimum of 6 inches (150 mm) shall be excavated or be available below the pipe for bedding material. In addition, soft or yielding material shall be removed and replaced with properly compacted bedding material.

### 730.4 Laying Pipe.

**730.4.1** Bedding material (material between the bottom of the trench and the bottom of the pipe) shall consist of well-graded crushed stone, gravel or sand, placed and well compacted. Crushed stone or gravel shall have 100 percent passing the 1 1/2 inch (37.5 mm) sieve and less than 50 percent passing the No. 4 (4.75 mm) sieve. Natural or manufactured sand shall have 100 percent passing the 1 1/2 inch (37.5 mm) sieve and more than 50 percent passing the No. 4 (4.75 mm) sieve. All material shall have less than 5 percent passing the No. 200 (75 µm) sieve, a plasticity index of 0 and be free of lumps, clods, frozen matter, debris, etc.

**730.4.2** Bedding material shall be a minimum of 6 inches (150 mm) deep and be placed in 6 inch (150 mm) maximum depth compacted lifts. The bedding material shall be leveled by hand and the pipe carefully laid true to lines and grades shown on the plans. If pipe sections are joined at the placement site, the ends shall be butted as closely as the corrugations will permit and be joined with approved coupling devices of the same material as the pipe. For multiple lines of pipe and diameters up to 48 inches (1200 mm), pipe spacing shall be such that the sides are no closer than one-half diameter or 3 feet (1 m), whichever is greater. For multiple lines and diameters greater than 48 inches (1200 mm), the minimum clear spacing shall be 2 feet (600 mm). Any pipe which is not in true alignment or which shows any undue settlement after laying shall be taken up and relaid or replaced at the contractor's expense. If shown on the plans or directed by the engineer, camber shall be built into the pipe structure to compensate for settlement from fill loads.

**730.4.3** Proper care shall be taken during handling and installation to avoid damage to the pipe and fittings. Pipe that is damaged will be rejected at the site of the work regardless of previous approvals.

**730.4.4** Pipe having localized bends, dents, split seams, holes or other defects that affect the durability or function of the pipe, will be rejected.

**730.5 Backfilling.** Backfilling consists of placing haunch, initial backfill and final backfill material. Haunch and initial backfill material shall meet the material, lift, and compaction requirements for bedding.

**730.5.1** Haunch material (material from the top of the bedding to the midpoint of the pipe) shall be carefully placed, worked around the pipe by hand and compacted to provide uniform support.

**730.5.2** Initial backfill material, material from the haunch to at least 1 foot (300 mm) or 1/2 pipe diameter, whichever is greater, above the top of the pipe, shall be placed and tamped with hand or vibratory compactors.

**730.5.3** Final backfilling shall continue using other suitable embankment material, compacted to a minimum of 90 percent standard maximum density or otherwise specified embankment density.

**730.6 End Finish.** If no other end section is specified, the ends of polyethylene pipe culverts to be exposed in the finished structure shall have approved coupling fitting attached so as to form a double thickness of polyethylene pipe for the full length of the coupling fitting.

**730.7 Method of Measurement.**

**730.7.1** Measurement of corrugated polyethylene culvert pipe, complete in place, will be made to the nearest foot (0.5 m) along the geometrical center of the pipe. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**730.7.2** Excavation for placing pipe will be measured and paid for as Class 3 Excavation in accordance with [Sec 206](#).

**730.8 Basis of Payment.**

**730.8.1** The accepted quantities of pipe, complete in place, including all necessary fittings will be paid for at the unit price for each of the pay items included in the contract. The accepted quantities of pipe by groups will be paid for in accordance with the item numbers, pay items and pay units listed in [Sec 725](#).

**730.8.2** No direct payment will be made for material or work required for placing couplings on exposed ends of the pipe.

**730.8.3** No direct payment will be made for any additional work required for laying pipe, nor for any backfilling required except as specified in [Sec 206.6.3](#).

## SECTION 731

### PRECAST REINFORCED CONCRETE MANHOLES AND DROP INLETS

**731.1 Description.** This work shall consist of furnishing and installing precast concrete manholes and drop inlets as shown on the plans.

**731.2 Material.**

**731.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Precast Reinforced Concrete Manhole and Drop Inlet Sections	<a href="#">1033</a>
Concrete Curing Material	<a href="#">1055</a>
Plastic Joint Compound for Vitrified Clay and Concrete Pipe	<a href="#">1057.3</a>
Tubular Joint Seal	<a href="#">1057.4</a>
Mortar for Pipe Joints	<a href="#">1066</a>

**731.2.2** Concrete for footings shall be Class B, Class, B-1, or concrete of a commercial mixture meeting the requirements of [Sec 501.14](#). Air entrainment will not be required. Concrete shall be placed and float finished. After finishing, concrete shall be cured in the same manner as required for concrete pavement except that transparent membrane shall be used in lieu of pigmented membrane.

**731.3 Construction Requirements.**

**731.3.1** Precast concrete manhole and drop inlet sections shall be carefully placed true to line and grade, and joints sealed in accordance with the applicable provisions of [Sec 726](#).

**731.3.2 Footings.** Footings shall be constructed to the size and shape shown on the plans. Forms will not be required.

**731.4 Method of Measurement.**

**731.4.1** Measurement of precast concrete manholes and drop inlets, complete in place, will be made to the nearest foot (0.5 m) as shown on the plans. The depth of the structure will be the vertical distance from the top of the uppermost precast section to the invert flowline. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**731.4.2** Excavation will be measured and paid for in accordance with [Sec 206](#). Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**731.5 Basis of Payment.**

**731.5.1** The accepted quantities of precast manholes and drop inlets, complete in place, including any necessary cutting or joining new pipe or existing pipe to the structure unless otherwise specified will be paid for at the unit price for each of the pay items included in the contract.

**731.5.2** No direct payment will be made for:

- (a) Backfilling except as specified in [Sec 206.6.3](#).
- (b) Footing Concrete.
- (c) Steps.
- (d) Weep holes, including excavation, permeable granular backfill, 4-inch (100 mm) drain tile, screen for inlet, or any other work incidental thereto.

## SECTION 732

### FLARED END SECTIONS

**732.1 Description.** This work shall consist of furnishing and installing precast concrete or metal flared end sections of the size and shape shown on the plans.

**732.1.1** Precast concrete flared end sections shall be used with concrete or vitrified clay culvert pipe.

**732.1.2** Metal flared end sections shall be used with metal culvert pipe.

**732.1.3** Safety slope end sections may be used with either concrete, plastic or metal culvert pipe.

#### **732.2 Material.**

**732.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Metal Flared End Sections	<a href="#">1020</a>
Precast Concrete Flared End Sections	<a href="#">1032</a>
Safety Bars and Longitudinal Bars	ASTM A-53 Schedule 40
Bar Grate	ASTM A575 Grade 1020
Plastic Joint Compound for Vitrified Clay and Concrete Pipe	<a href="#">1057.3</a>
Tubular Joint Seal	<a href="#">1057.4</a>
Mortar for Pipe Joints	<a href="#">1066</a>

**732.2.2** If toe walls for precast concrete flared end sections are cast-in-place, they shall be constructed of Class B or B-1 concrete, or concrete of a commercial mixture meeting the requirements of [Sec 501.14](#). Material, proportioning, air-entraining, mixing, slump and transporting of the portland cement concrete shall be in accordance with [Sec 501](#). Air-entrained concrete will not be required. Concrete shall be placed and cured in accordance with the applicable provisions of [Sec 703](#). If toe walls are precast, they may be constructed of any of the above specified concrete mixtures or they may be constructed of the same mixture used to fabricate the precast concrete flared end sections. Precast toe walls may be cured in accordance with [Sec 703](#) or in the same manner as the flared end sections.

#### **732.3 Construction Requirements.**

**732.3.1** Flared end sections shall be joined to pipes or pipe-arches as shown on the plans. They shall be carefully placed to the line and grade of the structure on a uniformly firm soil foundation shaped to fit the lower part of the end section.

**732.3.1.1 Precast Concrete Flared End Sections.** The joint material between the end section and the adjoining pipe shall be the same as that used for the pipe joints and shall be installed in the same manner. Toe walls shall be of the size and shape shown on the plans and may be precast or cast-in-place. Forming of cast-in-place toe walls will not be required.



**732.3.1.2 Metal Flared End Sections.** The end section shall be joined to the pipe or pipe-arch as shown on the plans. The toe plate, if specified, shall be set in a trench or driven to the proper elevation. Care shall be taken to avoid damage to the metal.

**732.3.2 Safety Slope End Section.** Safety slope end section shall consist of a metal-flared end section, a safety bar system or a bar grate system, toe plate extension, if required in the contract, and any fasteners required for attachment to the culvert pipe.

**732.3.2.1 Construction Requirements.** Safety slope end sections shall be attached as shown on the plans. They shall be carefully placed to the line and grade of the structure on a uniformly firm soil foundation shaped to fit the lower part of the end section.

**732.3.2.2 Toe Plate Extension.** The toe plate extension, if required in the contract, shall be attached to the end section as shown on the plans.

**732.3.2.3 Safety Bar System.** Safety bars are required on end sections used on culvert pipes 24 inch (600 mm) in diameter or greater. The number, size and spacing of safety bars shall be as shown on the plans.

**732.3.2.4 Bar Grate System.** In lieu of the safety bar system, the bar grate system may be used. If used, the bar grate system shall be fabricated and installed as shown on the plans.

**732.4 Basis of Payment.** The accepted quantity of flared end sections and safety slope end sections complete in place will be paid for at the contract unit price per each. No direct payment will be made for any excavation or bedding required for placement of the end section, nor for toe walls or toe plates.

## SECTION 733

### PRECAST CONCRETE BOX CULVERTS

**733.1 Description.** This work shall consist of furnishing and installing precast concrete box culverts.

**733.1.1** Unless otherwise required in the contract, where the construction of cast-in-place single or multi-cell reinforced concrete box culverts is specified, the contractor shall have the option of constructing such culverts using precast reinforced concrete box sections and headwalls subject to the conditions specified in the contract.

**733.2 Material.**

**733.2.1** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Precast Box Culverts	<a href="#">1049</a>
Plastic Joint Compound for Vitrified Clay and Concrete Pipe	<a href="#">1057.3</a>
Tubular Joint Seal	<a href="#">1057.4</a>
Mortars and Grout	<a href="#">1066</a>

**733.3 Construction Requirements.**

**733.3.1 Subgrade Preparation and Bedding.** The excavation and backfilling for the precast box sections and end sections shall be in accordance with the requirements of [Sec 206](#) except a layer of granular material at least 6 inches (150 mm) thick shall be placed immediately below the elevation of the bottom of the box and end sections. The granular material shall meet the requirements of [Sec 1007](#) for Types 1, 2 or 3 aggregate, and shall be placed to extend at least 18 inches (450 mm) each side of the structure. The bedding shall be compacted to provide uniform support for the bottom of the box and end sections. No direct payment will be made for furnishing, placing or compacting the granular material.

**733.3.2 Placement.** The individual box section shall be set to lines and grades shown on the plans with the groove end upstream, and the spigot end extended full length into the adjacent downstream section of box.

**733.3.2.1** All joints between individual box sections shall be sealed with an approved plastic joint compound or a tubular joint seal. Trowel grade compounds shall be applied to both mating surfaces. Rope or tape type plastic joint compounds and tubular joint seals shall be applied in accordance with the manufacturer's recommendations. The joints shall be forced together with excess compound extruding both inside and outside the joint. Excess compound shall be removed from the interior surface. The joint between the box sections shall be uniform for the full perimeter.

**733.3.2.2** Where lift holes as approved on the drawings have been used, the holes shall be filled with expansive mortar or tapered precast mortar plugs to provide a watertight section. The mortar shall be finished flush on the inside of the box and shall be properly cured on the outside. Tapered precast plugs shall be thoroughly sealed with plastic joint compound

material. Lifting devices shall have sufficient bearing on the inside of the box section to avoid damage resulting from a concentration of stresses around the lift holes.

**733.3.2.3** When multi-cell box culverts are used, a 1 1/2 inch (38 mm) minimum space shall be left between the adjacent precast sections. Following the installation of the end sections, the 1 1/2 inch (38 mm) space between the parallel sections shall be entirely filled with mortar for grout. After the mortar has attained sufficient strength, backfilling of the sections in accordance with [Sec 206](#) may begin.

**733.4 Method of Measurement.**

**733.4.1** If the contractor, at the contractor's option, constructs the alternate precast box culvert, measurement will be made as provided for the cast-in-place structure for Class B Concrete (Culverts) and Reinforcing Steel (Culverts).

**733.4.2** If precast box culvert is specified in the contract, precast box culvert, complete in place including end sections, will be measured to the nearest foot (0.5 m) along the geometrical center of the culvert floor. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity.

**733.5 Basis of Payment.**

**733.5.1** Accepted optional precast concrete box culvert, including end sections, will be paid for at the unit price for each of the pay items included in the contract for the cast-in-place concrete box culvert.

**733.5.2** If precast box culvert is specified in the contract, the accepted quantities for the concrete box culvert, complete in place including end sections, will be paid for at the unit price for the pay items included in the contract.

## SECTION 734

### JACKING PIPE

**734.1 Description.** This work shall consist of jacking reinforced concrete pipe culvert (gasket type) underneath existing pavements at locations shown on the plans in accordance with the following requirements.

**734.2 Materials.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Reinforced Concrete Culvert, Storm Drain and Sewer Pipe	1026

**734.2.1** The class of pipe specified in the contract item will be determined for vertical load only. Additional reinforcement or strength of pipe required to withstand jacking pressure shall be determined by the contractor and furnished at the contractor's expense.

**734.2.2** Temporary concrete traffic barrier shall comply with [Sec 617](#).

#### **734.3 Construction Requirements.**

**734.3.1** The contractor shall protect the pipe jacking work area with temporary concrete traffic barrier.

**734.3.1.1** On two-lane roadways with two-way traffic, 300 feet (90 m) of concrete traffic barrier shall be installed on the shoulder to protect the work area. The barrier shall be centered on the jacking pit. The first and last 100 feet (30 m) of barrier shall be tapered at a 25:1 ratio away from the traveled way. The center 100 feet (30 m) of barrier shall be parallel to the centerline of the roadway and 4 feet (1.2 m) from the outside edge of the shoulder. Approved crashworthy end terminals shall be installed on the exposed ends of the tapered sections.

**734.3.1.2** On divided and undivided multi-lane roadways, 200 feet (60 m) of concrete traffic barrier shall be installed on the shoulder to protect the work area. The first 100 feet (30 m) of barrier shall be centered on the jacking pit, parallel to the centerline of the roadway and 4 feet (1.2 m) from the outside edge of the shoulder. The second 100 feet (30 m) of barrier shall be installed on a 25:1 taper away from the traveled way in the direction of on-coming traffic. An approved crashworthy end terminal shall be installed on the end of the tapered section.

**734.3.2** Variations from theoretical alignment and grade for the completed jacked pipe shall not exceed 0.5 feet (150 mm) for each 100 feet (30 m) of pipe.

**734.3.3** The excavated hole shall not be more than 0.1 foot (30 mm) greater than the outside diameter of the pipe. Sluicing and jetting with water will not be permitted. When material tends to cave in from outside these limits, a metal shield shall be used ahead of the first section of pipe when jacking or pushing.

**734.3.4** If the excavated hole is formed by the horizontal boring method, the boring equipment used to bore the hole shall be of proper type and in proper working order to ensure the work is performed to the satisfaction of the engineer.

**734.3.5** The boring equipment shall be operated by experienced workers and in a manner meeting the approval of the engineer. Bored holes shall be cleaned of excess material before pipe is jacked or pushed into place.

**734.3.6** Any areas resulting from caving or excavation outside the above specified limits shall be backfilled with sand grout by a method which will fill the voids. The excavated area around the pipe shall be sealed with grout for a minimum distance of 3 feet (1 m) from the outside face of the fill or cut slope.

**734.3.7** If steel casing pipe, to be left in place, is used with this installation method, the contractor shall have the option to delete the gasket type joints for the limits of the jacked pipe.

**734.4 Method of Measurement.** Measurement of jacked pipe, complete in place, will be made to the nearest foot (meter) along the geometrical center of the pipe. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity. The length of structure may be increased by not more than 3 feet (1 m) as necessary to avoid cutting the pipe, but such increased length will not be included in the contract quantity for payment.

**734.5 Basis of Payment.**

**734.5.1** All cost for work area protection will be paid for at the contract unit price for each of the pay items included in the contract.

**734.5.2** The accepted quantities of jacked pipe, complete in place, will be paid for at the contract unit price. Payment will be considered full compensation for excavation and backfilling of the jacking pits, disposal of excess excavation from jacking or boring operations, sand or grout for filling voids, and any other incidental items or equipment necessary to complete the installation.



# **DIVISION 800**

***ROADSIDE  
DEVELOPMENT***





## SECTION 801

### FERTILIZING

**801.1 Description.** This work shall consist of the application of lime and commercial fertilizer and soil preparation for seeding and sodding on areas shown on the plans or designated by the engineer.

**801.2 Material.**

**801.2.1** Material used for soil neutralization, unless otherwise specified, shall be agricultural lime with not less than 90 percent passing the No. 8 (2.36 mm) sieve and containing not less than 65 percent calcium carbonate equivalent.

**801.2.2** The rate of application of lime shall be that required to provide at least the quantity of effective neutralizing material per acre (hectare) specified in the contract. Except as otherwise provided in this specification, the quantity of material required to provide the specified pounds (kilograms) of effective neutralizing material per acre (hectare) shall be determined from the producer or distributor's certification of analysis furnished by the Director of the Missouri Agriculture Experiment Station, Columbia, Missouri in accordance with the Missouri Agricultural Liming Materials Act.

**801.2.2.1** When agricultural lime is to be furnished from a source that has not been tested and certified in accordance with the Missouri Agricultural Liming Materials Act, the contractor shall notify the engineer at least 30 days prior to application of agricultural lime to permit sampling, testing and determination of the required rate of application. The engineer will determine the effective neutralizing material per ton of liming material by the following formula:

ENGLISH

$$\text{E.N.M.} = \frac{\% \text{ C.C.E.}}{100} \times \frac{\text{Fineness Factor}}{100} \times 800$$

where: E.N.M. is the Effective Neutralizing Material per ton. % C.C.E. is the percent Calcium Carbonate Equivalent as determined by Association of Official Analytical Chemists (AOAC) methods of analysis. Fineness Factor = (% passing No. 8 sieve and retained on the No. 40 x 0.25) + (% passing No. 40 sieve and retained on the No. 60 x 0.60) + (% passing No. 60). Gradation will be determined in accordance with AOAC wet sieving methods. The 800 is a constant representing the theoretical maximum quantity of calcium in one ton of lime.

METRIC

$$\text{E.N.M.} = \frac{\% \text{ C.C.E.}}{100} \times \frac{\text{Fineness Factor}}{100} \times 882$$

where: E.N.M. is the Effective Neutralizing Material per megagram. % C.C.E. is the percent Calcium Carbonate Equivalent as determined by Association of Official Analytical Chemists (AOAC) methods of analysis. Fineness Factor = (% passing 2.36 mm sieve and retained on the 425  $\mu\text{m}$  x 0.25) + (% passing 425  $\mu\text{m}$  sieve and retained on the 250  $\mu\text{m}$  x 0.60) + (% passing 250  $\mu\text{m}$ ). Gradation will be determined in accordance with AOAC wet sieving methods. The 882 is a constant representing the theoretical maximum quantity of calcium in one megagram of lime.

**801.2.2.2** If agricultural lime is furnished as a commercially bagged product, pelletized or otherwise, with a guaranteed product analysis shown on the bag listing the elemental properties and gradation, the E.N.M. shall be calculated in accordance with [Sec 801.2.2.1](#). Material may be accepted on the basis of bag label analysis.

**801.2.3** Fertilizer shall be a standard commercial product which, when applied at the proper rate, will supply the quantity of total nitrogen (N), available phosphoric acid (P<sub>2</sub>O<sub>5</sub>) and soluble potash (K<sub>2</sub>O), as specified in the contract. Material may be accepted on the basis of bag label analysis or supplier's certification and shall comply with all applicable Missouri fertilizer laws.

**801.3 Equipment.** Lime and commercial fertilizer shall be applied by mechanical equipment designed for this purpose.

**801.4 Construction Requirements.**

**801.4.1** The area to be limed and fertilized will be the area specified within the limits of construction; shall have a uniform surface free from rills, washes and depressions; and shall conform to the finished grade and cross section as shown on the plans. The soil shall be thoroughly broken up, worked, tilled and loosened to a minimum depth of 2 inches (50 mm). The seedbed or sodbed shall be prepared by loosening the existing soil on the slope, rather than by the addition of loose soil.

**801.4.2** Lime and fertilizer shall be applied evenly at the rates specified in the contract and only when the soil is in a tillable condition. After application, the lime and fertilizer shall be mixed into the soil by disking, harrowing or raking to a minimum depth of 2 inches (50 mm) unless applied hydraulically on slopes steeper than 2:1 (1:2) in accordance with [Sec 805.3.2.1](#).

**801.4.3** Lime and fertilizer shall be applied separately, but may be incorporated into the soil in one operation.

**801.4.4** Lime and fertilizer shall be applied not more than 48 hours before the seed is sown unless otherwise authorized by the engineer.

**801.5 Method of Measurement.** Measurement of the area which has been limed and fertilized will be made to the nearest 1/10 acre (0.1 hectare).

**801.6 Basis of Payment.** The accepted quantity of liming and fertilizing will be paid for at the contract unit price. No direct payment will be made for liming and fertilizing areas for which seeding or sodding items are included in the contract.

## SECTION 802

### MULCHING

**802.1 Description.** This work shall consist of the application of a mulch covering of the type specified in the contract. All seeded areas except shoulders shall be mulched. Disturbed areas outside of authorized construction limits shall be mulched at the contractor's expense.

#### **802.2 Material.**

**802.2.1 Type 1 Mulch (Vegetative).** The vegetative mulch shall be prairie hay or straw from oats, rye, wheat or barley. Prairie hay shall consist of any combination of any of the following plants: Big Bluestem, Little Bluestem, Indiangrass, Sideoats Grama and native wildflowers. The mulch shall be free of prohibited weed seed as stated in the Missouri Seed Law and shall be relatively free of all other noxious and undesirable seed. The mulch shall be clean and bright, relatively free of foreign material and be dry enough to spread properly. If the above specifications cannot be met practicably, hay of the following plants may, with the engineer's approval, be substituted: Smooth Brome, Timothy, Orchard Grass, Reed Canary Grass, Tall Fescue, Redtop, Kentucky Bluegrass, Alfalfa and Birdsfoot Trefoil.

**802.2.2 Type 2 Mulch (Vegetative with Asphalt Emulsion).** The asphalt emulsion shall be SS-1, SS-1h, CSS-1 or CSS-1h conforming to the requirements of AASHTO M 140 or AASHTO M 208. The vegetative mulch shall be as specified in [Sec 802.2.1](#).

**802.2.3 Type 3 Mulch (Vegetative with an Overspray).** The vegetative mulch shall be as specified in [Sec 802.2.1](#). The overspray material may be virgin wood cellulose fibers or recycled slick paper as herein specified. It shall not contain any germination or growth inhibiting substances. The overspray shall be green in color after application and shall have the property to be evenly dispersed and suspended when agitated in water. When sprayed uniformly over vegetative mulch, the mulch fibers shall form an absorbent cover, allowing percolation of water to the underlying soil. The mulch shall be packaged in moisture resistant bags with the net weight (mass) of the packaged material plainly shown on each bag. The mulch fibers shall not be water soluble.

**802.2.3.1** Virgin wood cellulose fibers shall be produced by either the ground or cooked fiber process and shall have the following properties:

Moisture Content, percent by weight (mass), max	15
Organic Matter-Wood Fiber, percent by weight (mass), min	80
pH	4.3-8.5

**802.2.3.2** Recycled slick paper mulch shall be produced from printers slick paper containing wood cellulose and kaolin clay. Recycled newsprint or cardboard will not be allowed. The material shall be free of other material or fillers and shall have the following properties:

Moisture Content, percent by weight (mass), max	8
pH	4.5-6.5

**802.2.3.3** The contractor shall furnish a manufacturer's certification in triplicate certifying that the overspray mulch materials complies with these specifications. The engineer may sample and test these materials prior to approval and use. Acceptance will be based upon a satisfactory certification and results of any test deemed necessary by the engineer.

**802.2.4 Type 4 Mulch (Embedded).** The vegetative mulch shall be as specified in [Sec 802.2.1](#). The mulch shall be embedded by a disk type roller having flat serrated disks spaced not more than 10 inches (255 mm) apart and cleaning scrapers shall be provided.

### **802.3 Construction Requirements.**

**802.3.1** Type 1 Mulch (Vegetative) shall be applied at the rate of 2 1/2 tons per acre (5.5 Mg/ha).

**802.3.2** Type 2 Mulch (Vegetative with Asphalt Emulsion) shall be applied by mechanical mulch spreaders equipped to eject, by means of a constant air stream, controlled quantities of the vegetative mulch and emulsified asphalt in a uniform pattern over the specified area. The mulching machine shall be so designed that the asphalt will be injected at the proper rate directly into the air stream carrying the straw, resulting in a uniform spotty tacking of the vegetative mulch with asphalt. The vegetative mulch shall be applied at the rate of 2 1/2 tons per acre (5.5 Mg/ha). The application rate for the asphalt emulsion shall be 100 gallons per ton (415 L/Mg) of straw.

**802.3.3** Type 3 Mulch (Vegetative with an Overspray) shall be hydraulically applied over the vegetative mulch as a separate operation. Recycled slick paper shall be applied at the rate of 750 pounds per acre (840 kg/ha). Virgin wood cellulose fibers with 90 percent or more organic matter shall be applied at the rate of 750 pounds per acre (840 kg/ha) and that with 80 to 89 percent inclusive shall be applied at a rate calculated as follows:

$$\frac{\text{ENGLISH}}{\text{Rate lb/acre}} = \frac{100}{\text{Actual Percent Organic Matter}} \times 750 \text{ lb/acre}$$

$$\frac{\text{METRIC}}{\text{Rate kg/ha}} = \frac{100}{\text{Actual Percent Organic Matter}} \times 840 \text{ kg/ha}$$

The overspray material shall be mixed with water in a manner to provide a homogeneous slurry. Equipment for mixing and applying the slurry shall be capable of applying it uniformly over the entire vegetative mulched area. The slurry mixture shall be agitated during application to keep the ingredients thoroughly mixed.

**802.3.4** Type 4 Mulch (Embedded) shall be applied at the rate of 2 1/2 tons per acre (5.5 Mg/ha). The mulch roller shall be operated approximately parallel to the roadbed grade. The mulch shall be embedded in the soil a sufficient depth to prevent the loss of mulch by wind or water erosion. Excelsior blanket may be used in lieu of Type 4 Mulch at the option of the contractor.

**802.3.5** All mulch shall be distributed evenly over the area to be mulched within 24 hours following the seeding operation. Following the mulching operation, precautions shall be taken to prohibit foot or vehicular traffic over the mulched area. Any mulch which is displaced shall be replaced at once, but only after the work preceding the mulching which may have been damaged as a result of the displacement has been acceptably repaired.

**802.4 Method of Measurement.** Measurement of Types 1, 2, 3 and 4 Mulch will be made to the nearest 1/10 acre (0.1 hectare) of the area mulched.

**802.5 Basis of Payment.** The accepted quantities of mulch will be paid for at the unit price for each of the pay items included in the contract.

## SECTION 803

### SODDING

**803.1 Description.** This work shall consist of preparing the areas for sodding and placing approved live sod. The entire area specified for sodding shall be covered with sod.

**803.2 Material.** The sod shall be Kentucky Bluegrass, densely rooted and thrifty. The sod shall contain a growth of not more than 25 percent of other grasses and clovers, be free from all prohibited and noxious weeds and be reasonably free of all weeds. The sod shall be cut in strips of uniform thickness with each strip containing at least 1/3 square yard (0.2 m<sup>2</sup>). Sod shall be cut into strips not less than 12 inches (300 mm) wide. At the time of sod lifting, length of the top growth shall not exceed 3 inches (75 mm). The thickness of the sod shall be determined by stacking ten pieces alternately with the soil of the first piece on the bottom. The height of the stack, without compression, shall exceed 11 inches (280 mm) and the thickness of the soil portion of each piece shall be not less than 3/4 inch (20 mm). All sod shall conform to the laws of Missouri and shall be obtained from sources meeting the approval of the Department of Agriculture, Plant Industries Division.

#### **803.3 Construction Requirements.**

**803.3.1** Sod shall not be placed during a drought nor during the period from June 1 to September 1, unless otherwise authorized by the engineer, and shall not be placed on frozen ground. No dry or frozen sod shall be used.

**803.3.2** The sodbed shall be prepared, limed and fertilized in accordance with [Sec 801](#). The bed shall be in a firm but uncompacted condition with a relatively fine texture at the time of sodding. Sod shall be moist and shall be placed on a moist earth bed. Sod strips shall be laid along contour lines and adjusted as necessary, beginning at the base of the area to be sodded and working upward. The transverse joints of sod strips shall be broken and the sod carefully laid to produce tight joints. The sod shall be firmed, watered and refirmed immediately after it is placed. The firming shall be accomplished by use of a lawn roller or tamper. On 3:1 (1:3) slopes or steeper, the sod shall be pegged with wood pegs approximately 1/2 inch x 12 inches (15 x 300 mm) driven into ground, leaving about 1/2 inch (15 mm) of the peg above the sod, and spaced not more than 2 feet (600 mm) apart. Pegging of sod shall be done immediately after the sod has been firmed. When sodding is completed, the sodded areas shall be cleared of loose sod, excess soil or other foreign material, and a thin application of topsoil shall be scattered over the sod as a top dressing and the areas thoroughly moistened.

**803.3.3** The contractor shall keep all sodded areas thoroughly moist for 21 days after laying. The sod shall be living at the time of acceptance of the area.

**803.4 Method of Measurement.** Measurement will be made to the nearest square yard (square meter) of approved sodded surface area.

**803.5 Basis of Payment.** The accepted quantities of sodding will be paid for at the contract unit price. No direct payment will be made for liming or fertilizing sodded areas.

## SECTION 804

### TOPSOIL

**804.1 Description.** This work shall consist of approved selected topsoil furnished and placed at the locations shown on the plans in the manner specified.

**804.2 Material.** Topsoil shall be obtained from approved sources. It shall be a fertile, friable and loamy soil of uniform quality, without admixture of subsoil material, and shall be free from material such as hard clods, stiff clay, hardpan, partially disintegrated stone, pebbles larger than one inch (25 mm) in diameter and any other similar impurities. Topsoil shall be relatively free from grass, roots, weeds and other objectionable plant material or vegetative debris undesirable or harmful to plant life or which will prevent the formation of a suitable seedbed.

#### **804.3 Construction Requirements.**

**804.3.1** The engineer shall be notified sufficiently in advance of the opening of any material source to permit the engineer to prepare for necessary checking and measurement. Topsoil shall be secured from areas from which the topsoil has not been previously removed, either by erosion or mechanical methods. The soil shall not be removed in excess of the depth approved by the engineer. Unless otherwise shown on the plans, the source of material shall be furnished by the contractor. During the period of removal of the topsoil material, the site shall be kept drained, and when all material has been removed, the site shall be left in a neat and presentable condition.

**804.3.2** The surface on which the topsoil is to be placed shall be free of all loose rock and foreign material greater in any dimension than one-half the depth of the topsoil to be added. It shall be raked or otherwise loosened just prior to being covered with topsoil. Topsoil shall be placed and spread over the designated areas to a depth sufficiently greater than shown on the plans so that after settling, the completed work will conform with the thickness shown on the plans. After spreading, all large clods and foreign material shall be removed by the contractor.

**804.4 Method of Measurement.** Topsoil will be measured to the nearest cubic yard (cubic meter) of material in vehicles at the point of delivery.

**804.5 Basis of Payment.** The accepted quantity of topsoil will be paid for at the contract unit price. Overhaul will not be paid on topsoil.

## **SECTION 805**

### **SEEDING**

**805.1 Description.** This work shall consist of preparing, liming and fertilizing a seedbed, and the furnishing and sowing of seed as specified in the contract. All disturbed areas shall be seeded except: (1) sodded areas, (2) surfaced areas, (3) solid rock and (4) slopes consisting primarily of broken rock. Disturbed areas outside of authorized construction limits shall be seeded at the contractor's expense.

#### **805.2 Material.**

**805.2.1** The seed shall be grown and processed in the United States or Canada and comply with the requirements of the Missouri Seed Law. The following percentages for purity and germination or pure live seed will be the minimum requirements in the acceptance of seed, unless otherwise permitted by the engineer.



	Purity	Germination Including Hard Seed	Pure Live Seed	Germination <sup>a</sup> Excluding Hard Seed	Maximum Percent Weed Seed
Bermuda Grass	95	80			1.00
Smooth Brome Grass	85	80			2.00
Kentucky Bluegrass	85	80			1.00
Orchard Grass	85	80			2.00
Perennial Rye Grass	98	85			1.00
Annual Rye Grass	98	85			1.00
Sudan Grass	98	85			1.00
Reed Canary Grass	97	75			1.00
Timothy	98	85			1.00
Redtop	92	85			2.00
Oat Grain	98	85			1.00
Rye Grain	98	80			1.00
Wheat Grain	97	85			0.25
Tall Fescue	97	85			2.00
Red Fescue	97	85			1.00
Korean Lespedeza	98	85		55	1.00
Sericea Lespedeza	98	85		55	1.00
Alsike Clover	98	85		55	1.00
Red Clover	98	85		55	1.00
Sweet Clover	98	85		55	1.00
White Clover	98	85		55	1.00
Hairy Vetch	97	80		50	1.00
Crown Vetch	98	70		40	1.00
Birdsfoot Trefoil	98	80		50	1.00
Big Bluestem (Debearded)			40		2.00
Blue Grama			40		2.00
Buffalograss			65		2.00
Indiangrass (Debearded)			50		2.00
Little Bluestem (Debearded)			40		2.00
Sand Lovegrass			70		1.00
Sideoats Grama			40		2.00
Switchgrass			80		1.00
Weeping Lovegrass			80		1.00

<sup>a</sup> Does not apply if unhulled or unscarified seed is specified.

**805.2.1.1** If the specified quantity is in pounds (kilograms) of seed, no reduction will be permitted in the specified quantity of seed if the purity or germination, or both, are higher than the minimum required by the specifications. If the specified quantity is in pounds (kilograms) of pure live seed, the pure live seed quantity shall be determined from the actual percentage shown by the supplier for native grasses or by multiplying the actual percentages of purity times the actual percentage of germination including hard seed for other seed.

**805.2.2** All leguminous seed shall be inoculated or treated with the proper quantity of cultures approved for the particular legume to be sown. Leguminous seed include Alsike Clover,

Korean Lespedeza, Red Clover, Sericea Lespedeza, Sweet Clover, White Clover, Hairy Vetch, Crown Vetch and Birdsfoot Trefoil.

**805.2.2.1** The inoculant for treating leguminous seed shall be a pure culture of nitrogen-fixing bacteria. The containers of the inoculant shall be plainly marked with the expiration date for use and the manufacturer's directions for inoculating seed.

**805.2.2.2** The process of inoculation shall be in accordance with the manufacturer's directions for the particular species of legume. The time lapse for sowing the seed following inoculation shall not exceed 24 hours. If hydraulic slurry seeding is used, a quantity of inoculant equal to five times the normal rate required to inoculate only the legume seed shall be used. The inoculant shall be placed directly into the slurry and thoroughly mixed immediately before seeding. If other than the hydraulic slurry method is used, the legume seed may be inoculated at the normal rate if it is to be sown alone or if the legume seed is inoculated prior to mixing with other seed. A seed mixture which contains a legume that was not inoculated prior to mixing and is not to be seeded by the slurry method, shall be inoculated with sufficient inoculant to cover all seed.

### **805.3 Construction Requirements.**

**805.3.1** The seedbed shall be prepared, limed and fertilized in accordance with [Sec 801](#) and shall be in a firm but uncompacted condition with a relatively fine texture at the time of seeding.

**805.3.2** During the months of December through May, August and September, all lime, fertilizer, seed and mulch shall be applied to the finished slopes. During the months of June, July, October and November, lime, fertilizer, seed and mulch shall be applied at the following rates:

Lime	100 percent of the specified quantity
Fertilizer	75 percent of the specified quantity
Seed	50 percent of the specified quantity
Mulch	100 percent of the specified quantity

Seeding shall be done before the proposed seedbed becomes eroded, crusted over or dried out and shall not be done when the ground is in a frozen condition or covered with snow. When the partial application has been made during June, July, October or November, the remainder of the fertilizer plus 75 percent of the specified quantity of seed shall be applied by overseeding during August, September, December, January or February. Seed shall be uniformly applied at the rates specified. Provisions shall be made by markers or other means to ensure that the successive seeded strips will overlap or be separated by a space no greater than the space left between the rows planted by the equipment being used. If inspection during the seeding operations indicates that strips wider than the space between rows planted have been left unplanted, additional seed shall be planted on these areas.

**805.3.2.1 Hydraulic Seeding and Fertilizing.** In lieu of mechanical application of seed and fertilizer, hydraulic application may be used. On slopes steeper than 2:1 (1:2), or way when seeding is applied to a previously seeded and mulched area, seed and fertilizer may be applied hydraulically in a single operation and incorporation into the soil will not be required. On all other slopes, seed and fertilizer may be applied hydraulically provided the seed and fertilizer are applied separately. The seed and fertilizer shall be incorporated into the soil as specified in [Sec 801.4.2](#) and [805.3.2.2](#), in separate operations except that raking will not be required when seeding a previously seeded and mulched area. Seed and fertilizer, separately or in combination, shall be mixed with water and constantly agitated so that a uniform mixture can

be applied hydraulically to the specified areas. The ratio of seed and fertilizer to water shall be calculated by determining the number of square feet (square meters) covered by a given quantity of water. Seed shall not be added to the water more than 4 hours before application.

**805.3.2.2 Dry Seeding.** Dry seeding shall be done mechanically with equipment designed for even distribution of dry seed. The equipment may either be hand operated, such as knapsack seeder, or be tractor-drawn, such as seed drill, except that tractor-drawn equipment will not be permitted on a previously seeded and mulched area. Seed scattered on the surface shall be covered with approximately 1/4 inch (5 mm) of soil by raking or other approved methods except that raking will not be required when seeding a previously seeded and mulched area. Seed placed in the soil shall be approximately 1/4 inch (5 mm) below the surface. After completing the seeding operation, the contractor shall firm the area by rolling, if in the judgment of the engineer the seedbed is either too loose or contains clods which would reduce the germination of the seed. When rolling is required, a lawn-type roller shall be used and care shall be taken to avoid over-compacting the soil.

**805.4 Method of Measurement.** Measurement will be made of the area seeded to the nearest 1/10 acre (0.1 hectare).

**805.5 Basis of Payment.** The accepted quantity of seeding will be paid for at the contract unit price. No direct payment will be made for liming or fertilizing seeded areas. No direct payment will be made for additional work and seed required when seeding during the months of June, July, October and November.

## SECTION 806

### EROSION AND SEDIMENT CONTROL

**806.1 Description.** This work shall consist of furnishing, installing, maintaining and removing temporary erosion and sediment control measures; furnishing and placing permanent erosion control features; or a combination of both as shown on the plans or as designated by the engineer. The work shall consist of controlling water pollution in accordance with these specifications.

**806.1.1** The contractor shall exercise best management practices throughout the life of the project to control water pollution. Pollutants such as chemicals, fuels, lubricants, bitumen, raw sewage or other harmful material shall not be discharged from the project. Temporary pollution control measures shall be coordinated with permanent erosion control features specified in the contract to ensure economical, effective and continuous erosion control. This work shall also apply to work within easements designated by the Commission.

**806.2 Schedule of Work.** Prior to the preconstruction conference and the start of construction, the contractor shall submit schedules for the implementation of temporary and permanent erosion control work, as applicable for clearing and grubbing, grading, bridges and other structures at watercourses, construction and paving. No work shall be started until the erosion control sequences and methods of operations have been approved by the engineer.

**806.3 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Fertilizer and Lime	<a href="#">801</a>
Straw for Bales	<a href="#">802</a>
Mulching	<a href="#">802</a>
Seed	<a href="#">805</a>
Geotextile Fabric	<a href="#">1011</a>

**806.4 Construction Requirements.** The engineer may limit the surface area of erodible earth material exposed by clearing and grubbing or by excavation, borrow and fill operations. The engineer may direct the contractor to provide immediate permanent or temporary pollution control measures to prevent contamination of adjacent streams or other watercourses, lakes, ponds or other areas of water impoundment. Such work may involve the construction of temporary berms, dikes, dams, sediment basins, slope drains, and use of temporary mulches, seeding or other control devices or methods as necessary to control erosion.

**806.4.1** The contractor shall incorporate all permanent erosion control features into the project at the earliest practicable time. Temporary pollution control measures shall be used to correct conditions that develop during construction which were not foreseen during the design stage; that are needed prior to installation of permanent pollution control features; or that are needed temporarily to control erosion that develops during normal construction practices, but are not associated with permanent control features on the project.

**806.4.2** Clearing and grubbing operations shall be scheduled and performed so grading operations and erosion control features will follow immediately thereafter. The surface area of erodible earth material exposed at one time by clearing and grubbing, excavating fill or borrow shall not exceed 435,000 square feet (40,000 m<sup>2</sup>) within any individual drainage area

without installation of erosion controls for that drainage area. The total erodible surface area exposed at one time for the entire project shall not exceed 750,000 square feet (70,000 m<sup>2</sup>).

**806.4.3** The engineer will limit the area of clearing and grubbing, excavation, borrow and embankment operations with the contractor's progress in keeping the finished grading, mulching, seeding and other such permanent pollution control measures current. Should seasonal limitations make such operations unrealistic, temporary erosion control measures shall be taken immediately.

**806.4.4** Unless otherwise provided or approved in writing by the engineer, construction operations in rivers, streams and impoundments shall be restricted to those areas which must be entered for the construction of temporary or permanent structures. Rivers, streams and impoundments shall be promptly cleared of all falsework, piling, debris or other obstructions placed therein or caused by construction operations.

**806.4.5** Frequent fording of live streams with construction equipment will not be permitted. Temporary bridges or other structures shall be used wherever an appreciable number of stream crossings are necessary. Unless otherwise approved in writing by the engineer, mechanized equipment shall not be operated in live streams except as may be required to construct channel changes and temporary or permanent structures. If a Corps of Engineer Section 404 or Department of Natural Resources Section 401 permit is applicable for a project, the permit requirements and conditions shall prevail.

**806.4.6** The location of all local material pits, other than commercially operated sources, and all excess material areas shall be subject to the approval of the engineer. Erosion from construction operations and pollution control measures shall not cause water pollution.

**806.4.7** In the event of conflict between these requirements and the pollution control laws, rules or regulations of other federal, state or local agencies, the more restrictive laws, rules or regulations shall apply.

**806.4.8** At the engineer's discretion, removal requirements for all temporary erosion control features, with the exception of slope drains, may be waived.

#### **SECTION 806.10 TEMPORARY BERMS**

**806.10.1 Description.** This work shall consist of constructing temporary berms of compacted soil at the top of fill slopes or transverse to centerline on fills.

**806.10.2 Material.** Temporary berms shall consist of graded material from the site or any suitable material approved by the engineer.

##### **806.10.3 Construction Requirements.**

**806.10.3.1 Type A Berms.** Type A berms shall be constructed to the approximate dimensions as shown on the plans. These berms shall be machine compacted with a minimum of one pass over the entire width of the berm.

**806.10.3.2 Type B Berms.** Type B berms shall be constructed to the approximate dimensions as shown on the plans. These berms shall be machine compacted with a minimum of three passes over the entire width of the berm. Material removed from Type B berms shall be incorporated in the embankment when possible. The contractor shall dispose any excess or unsuitable material to a location as directed by the engineer.

**806.10.3.3 Type A and Type B Berms.** Temporary berms shall drain to a compacted outlet at a slope drain. On transverse berms, the top width of the berms may be wider and the side slopes flatter to allow equipment to pass over these berms with a minimal disruption.

**806.10.4 Method of Measurement.**

**806.10.4.1** Measurement of Type A berms will not be made directly as this item is a part of the excavation operations which will be included in other grading operations measured to the nearest cubic yard (cubic meter).

**806.10.4.2** Measurement of Type B temporary berms will be made to the nearest linear foot (meter).

**806.10.5 Basis of Payment.**

**806.10.5.1** Payment for the accepted quantities of Type A berms will be made at the contract unit price for the applicable item of Class A or Unclassified Excavation and will be full compensation for all work involved in constructing, maintaining and removing Type A Berms.

**806.10.5.2** Payment for Type B berms will be made at the contract unit price per linear foot (meter) and will be full compensation for installation, maintenance, removal and any other work noted on the plans.

**806.10.5.3** Any hand work at slope drain inlets will be a part of the contract unit price for slope drains.

**SECTION 806.20 TEMPORARY SLOPE DRAINS**

**806.20.1 Description.** This work shall consist of constructing temporary slope drains to carry water down slopes and to reduce erosion. The method selected shall be approved by the engineer prior to construction.

**806.20.2 Construction Requirements.** Temporary slope drains shall consist of a temporary facility of stone, concrete or asphalt gutters, half-round pipe, metal pipe, plastic pipe or flexible rubber pipe. The contractor shall provide temporary slope drains to carry water or water with suspended solids from cut sections down fill slopes until permanent facilities are installed. The contractor shall provide temporary slope drains on fill slopes at approximately 500 foot (150 m) intervals or as directed by the engineer. All temporary slope drains shall be adequately anchored to the slope to prevent disruption of flow. The inlet end shall be properly constructed to channel water into the temporary slope drain. The outlet ends of these temporary slope drains shall have some means of dissipating the energy of the water to reduce erosion downstream. Unless otherwise specified by the engineer, all temporary slope drains shall be removed by the contractor after permanent facilities are installed. The contractor shall restore the site to match the surroundings.

**806.20.3 Method of Measurement.** Measurement of temporary slope drains will be made to the nearest linear foot (meter).

**806.20.4 Basis of Payment.** The accepted quantities of temporary slope drains will be paid for at the contract unit price per linear foot (meter) and will be full compensation for all labor, equipment and material to complete the described work.

## **SECTION 806.30 TEMPORARY DITCH CHECKS**

**806.30.1 Description.** This work shall consist of constructing temporary ditch checks, removing sediment deposits at these locations and disposing of the sediment deposits at a location approved by the engineer.

### **806.30.2 Construction Requirements.**

**806.30.2.1 Rock Ditch Checks.** Rock ditch checks shall be constructed of 2 inch (50 mm) to 3 inch (75 mm) clean gravel or limestone. The gravel shall be placed according to the configuration shown on the plans. Hand or mechanical placement will be allowed. Rock ditch checks shall completely cover the ditch or swale, and the center of the rock ditch checks shall be lower than the edges.

**806.30.2.2 Straw Bale Ditch Checks.** Straw bale ditch checks shall be constructed according to the plans and specifications for the ditch application of the straw bale ditch check.

**806.30.2.3 Silt Fence Ditch Checks.** Silt fence ditch checks shall be constructed according to the plans and specifications for the ditch application of the silt fence ditch check.

**806.30.3 Maintenance.** The contractor shall replace ditch checks at the request of the engineer. Periodic sediment removal shall include removal and disposal of sediment in a location where it will not erode into construction areas or watercourses.

**806.30.3.1 Ditch Checks.** The contractor shall check the ditch checks for sediment accumulation after each storm event and shall remove the sediment when deposits reach approximately one-half of the original height. Sediment removal shall include removal and disposal.

**806.30.3.2** For rock ditch checks, the contractor shall make regular inspections to ensure the center of the check is lower than the edges. The contractor shall immediately correct erosion caused by high flows around the edges of the check.

**806.30.4 Method of Measurement.** Measurement of the removal of accumulated sediment will be made to the nearest cubic yard (cubic meter).

### **806.30.5 Basis of Payment.**

**806.30.5.1** The accepted quantities of ditch checks complete, accepted and in place will be paid for at the contract unit price per each of the pay items included in the contract and will be full compensation for all labor, equipment and material to complete the described work. This includes maintaining and repairing the original structure and the removal and disposal of the ditch check after completion of the work. The contractor will be compensated if the engineer determines unusual conditions warrant a repair or replacement of a ditch check.

**806.30.5.2** The removal of accumulated quantity of sediment will be paid for at the contract unit price per cubic yard (cubic meter). Payment will be full compensation for all labor, equipment and material to complete the described work and for sediment removal and disposal.

## **SECTION 806.40 SEDIMENT BASINS**

**806.40.1 Description.** This work shall consist of constructing sediment basins as shown on the plans or as determined by the engineer to trap and store sediments that occur in spite of temporary erosion control measures in use.

**806.40.2 Construction Requirements.** The area where a sediment basin is to be constructed shall be cleared of vegetation to enable removal of sediment. The sediment basin shall be an excavated or dammed storage area with rock riprap placed in inlet and outlet areas with defined side slopes.

**806.40.2.1** The inlet of a sediment basin shall be constructed with a wide cross-section and a minimum grade to prevent turbulence and to allow deposition of soil particles. When the depth of sediment reaches 1/3 of the structure's depth in any part of the pool, all accumulation shall be removed.

**806.40.2.2** Sediment basins shall remain in service until all disturbed areas draining into the structure have been satisfactorily stabilized. When use of a temporary sediment basin is to be discontinued, all excavations shall be backfilled and properly compacted. The contractor shall remove any sediment material and shall restore the existing ground to its natural or intended condition. The contractor shall dispose both accumulated sediment and excavated material removed during the construction of the sediment basin in locations that the sediment will not again erode into the construction areas or into natural waterways.

**806.40.3 Method of Measurement.** Measurement of sediment basin excavation and removal of accumulated sediment in temporary sediment basins will be made to the nearest cubic yard (cubic meter). Measurement of all seeding and mulching required after the sediment basin is built, after removal of the sediment basin, and site restoration will be made to the nearest 1/10 acre (0.05 ha).

### **806.40.4 Basis of Payment.**

**806.40.4.1** The accepted quantities for excavation of a sediment basin will be paid for at the contract unit price per cubic yard (cubic meter) and will be full compensation for all excavation, disposal of excavated material, removal and restoration when no longer required, along with the furnishing of rock riprap for inlet and outlet control. Sediment removal from sediment basins will be paid for at the contract unit price per cubic yard (cubic meter). All seeding and mulching required after the sediment basin is built, after removal of the sediment basin and site restoration, will be paid for at the contract unit price for the applicable temporary or permanent seeding and mulching.

**806.40.4.2** If additional clearing and grubbing is necessary for construction of a sediment basin, payment will be included in the contract unit price for sediment basin.

## **SECTION 806.50 TEMPORARY SEEDING AND MULCHING**

**806.50.1 Description.** This work shall consist of fertilizing, furnishing and sowing of seed, Type 1 mulching or other acceptable cover authorized by the engineer. This work shall produce a quick ground cover to reduce erosion in disturbed areas expected to be redisturbed at a later date. Finished grading of areas will not be required. Hydraulic seeding and fertilizing in accordance with [Sec 805](#) will be allowed.

**806.50.2 Construction Requirements.** Seeding and mulching shall be a continuous operation on all cut and fill slopes, excess material sites and borrow pits during the



construction process. All disturbed areas shall be seeded and mulched as necessary to eliminate erosion.

**806.50.2.1** The contractor shall provide permanent seeding and mulching as shown on the plans following temporary seeding.

**806.50.2.2** Temporary seeding mixtures of oats, cereal rye or wheat shall be applied at a rate of 100 pounds per acre (110 kg/ha). Temporary seeding mixtures of oats shall be applied only during the months of December through May.

**806.50.2.3** Temporary mulch placed over temporary seed mixtures shall be applied in accordance with [Sec 802.2.1](#).

**806.50.2.4** Fertilizer shall be applied at a rate of 40 pounds (45 kg) nitrogen (N) per acre (hectare).

**806.50.2.5** Lime will not be required for temporary seeding.

**806.50.3 Method of Measurement.** Measurement of all temporary seed mixtures and accompanying mulch will be made to the nearest 1/10 acre (0.05 ha).

**806.50.4 Basis of Payment.** The accepted quantities of all temporary seed mixtures and the accompanying mulch will be paid for at the contract unit price per acre (hectare).

## **SECTION 806.60 STRAW BALES**

**806.60.1 Description.** This work shall consist of furnishing, installing, maintaining and disposing bales of straw or other approved foliage used as a means of controlling pollution and erosion.

**806.60.2 Material.** The bales shall be Type 1 mulch meeting [Sec 802](#).

### **806.60.3 Construction Requirements.**

**806.60.3.1** The contractor shall place bales at the bottom of embankment slopes to divert runoff from sheet flow and to catch some of the sediment picked up in the sheet flow, as ditch checks in small ditches and drainage areas, or on the lower side of cleared areas to catch sediment from sheet flow. When used to trap sediment or divert runoff, the bales shall be adequately anchored to withstand the applied load. When used as a ditch check in small ditches and drainage areas, the bales shall be embedded.

**806.60.3.2** If directed by the engineer, the contractor shall dispose of bales used in ditch checks at an approved location.

**806.60.4 Method of Measurement.** Measurement of bales for temporary erosion will be made to the nearest linear foot (0.5 m).

**806.60.5 Basis of Payment.** The accepted quantities of bales for temporary erosion will be paid for at the contract unit price per linear foot (0.5 m). Payment will be full compensation for all labor, equipment and material to complete the described work and disposing of the bales when no longer required.

## SECTION 806.70 TEMPORARY SILT FENCE

**806.70.1 Description.** This work shall consist of furnishing, installing, maintaining and removing a wire-supported or self-supported geotextile silt fence designed to remove suspended particles from water passing through the fence and prevent sediment from polluting nearby streams and rivers. The quantities of temporary silt fence shown on the plans may be increased or decreased at the direction of the engineer. At the engineer's discretion, the location may be modified to fit field conditions. Such variations in quantity will not be considered as alterations in the details of construction or a change in the character of the work.

**806.70.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Geotextile, Type 2	<a href="#">1011</a>

**806.70.2.1 Posts.** Wood, steel or synthetic posts may be used. Posts shall be of sufficient length, not less than 4 feet (1.2 m), to ensure adequate embedment while fully supporting the silt fence and shall have sufficient strength to resist damage during installation and to support applied loads while in service.

**806.70.2.2 Support Fence.** All geotextile silt fence shall be supported either externally by wire or other approved mesh to a height of at least 24 inches (600 mm) or by a suitable designed-in support system capable of keeping the material erect. Either method shall be strong enough to withstand applied loads.

**806.70.2.3 Prefabricated Fence.** Prefabricated fence systems may be used provided they meet all of the above material requirements.

### 806.70.3 Construction Requirements.

**806.70.3.1** The contractor shall install a temporary silt fence as shown on the plans and at other locations as directed by the engineer. Fence construction shall be adequate to handle the stress from hydraulic and sediment loading. Fabric at the bottom of the fence shall be buried a minimum of 6 inches (150 mm) so that no flow can pass under the barrier. The trench shall be backfilled and the soil compacted over the fabric. The fabric shall be spliced together only at a support post with a minimum 6-inch (150 mm) overlap. Any installation method acceptable to the engineer will be allowed as long as the effectiveness and intent of the silt fence is achieved. All geotextile construction shall be in accordance with [Sec 624](#).

**806.70.3.2** Post spacing shall not exceed 5 feet (1.5 m). Posts shall be driven a sufficient depth into the ground or placed on closer spacing as necessary to ensure adequate resistance to applied loads.

**806.70.3.3** The silt fence shall be fastened securely to the upslope side of the post. When wire support fence is used, the wire shall extend into the trench a minimum of 2 inches (50 mm).

**806.70.3.4** The contractor shall maintain the integrity of silt fences as long as they are necessary to contain sediment runoff. The contractor shall inspect all silt fences immediately after each rainfall and at least daily during prolonged rainfall. Any deficiencies shall be immediately corrected by the contractor. In addition, the contractor shall make a daily review of the location of silt fences in areas where construction activities have changed the natural contour and drainage runoff to ensure the silt fences are properly located for effectiveness.

Where deficiencies exist, additional silt fences shall be installed as approved or directed by the engineer.

**806.70.3.5** The contractor shall remove and dispose of sediment deposits when the deposit approaches one-half the height of the fence or sooner when directed by the engineer. If required by heavy sediment loading, a second silt fence shall be installed as directed by the engineer.

**806.70.3.6** The silt fence shall remain in place until the engineer directs it be removed. Upon removal, the contractor shall remove and dispose of any excess silt accumulations, grade and dress the area to the satisfaction of the engineer, and establish vegetation on all bare areas in accordance with the contract requirements. The fence material shall remain the property of the contractor and may be used at other locations, provided the material continues to meet the requirements of this specification, is sound and not weakened by exposure to the elements.

**806.70.4 Method of Measurement.** Measurement of temporary silt fence will be made to the nearest linear foot (meter). The temporary silt fence will be measured in place from end post to end post of each separate installation completed and approved in place.

**806.70.5 Basis of Payment.** The accepted quantities of temporary silt fence completed, accepted and in place will be paid for at the contract unit price per linear foot (meter) and will be full compensation for all labor, equipment and material to complete the described work.

#### **SECTION 806.80 TEMPORARY PIPE**

**806.80.1 Description.** This work shall consist of installing temporary pipe of any material acceptable to the engineer, utilized to carry water under temporary roadways, silt fences, berms or other locations as determined by the engineer and to prevent the contractor's equipment from coming in direct contact with the water when crossing an active stream or intermittent streams created during heavy rainfalls.

**806.80.2 Construction Requirements.** Installation of temporary pipe shall be in accordance with the specifications for permanent pipe and shall prevent water from causing erosion around the pipe. All backfill material for pipes shall be placed in 6-inch (150 mm) lifts and mechanically compacted. Compaction tests will not be required.

**806.80.3 Method of Measurement.** Measurement of temporary pipe will be made to the nearest linear foot (0.5 m).

**806.80.4 Basis of Payment.** The accepted quantities of temporary pipe complete, accepted and in place will be paid for at the contract unit price per linear foot (0.5 m) and will be full compensation for all labor, equipment and material to complete the described work.

#### **SECTION 806.90 BLANKETS AND NETTING**

**806.90.1 Description.** This work shall consist of furnishing and placing erosion control blankets or netting at locations shown on the plans or as designated by the engineer.

##### **806.90.2 Material.**

**806.90.2.1 Plastic Netting.** Netting shall consist of a green degradable polypropylene extruded oriented plastic net with bonded joints having openings not to exceed 4 1/2 square inches (2900 mm<sup>2</sup>) with either dimension not to exceed 3 inches (75 mm). Excelsior blanket,

[Sec 806.90.2.2](#), may be used in lieu of plastic netting, in which case the excelsior blanket will serve as a substitute for both netting and mulch.

**806.90.2.2 Excelsior Blanket.** Excelsior blanket shall consist of a machine produced mat of wood excelsior with approximately 80 percent of the fibers having a minimum length of 6 inches (150 mm). The wood from which the excelsior is cut shall be properly cured to achieve adequately curled and barbed fibers. The blanket shall be of consistent thickness, with the fibers evenly distributed over the entire area of the blanket. The blanket shall be covered on the top side with a netting having a maximum mesh size of 1 1/2 inches x 3 inches (38 mm x 75 mm), composed of cotton cord, twisted Kraft paper yarn or degradable extruded plastic. The netting shall be entwined with the excelsior mat for maximum strength and ease of handling. The blanket shall be made smolder resistant with a treatment that shall be nonleaching, non-toxic to vegetation and shall not be toxic or injurious to humans. The blanket shall meet the following requirements.

(a) Weight (Mass) - 0.75 pound per square yard (0.4 kg/m<sup>2</sup>), minimum.

(b) Smolder Resistance - Blanket in air-dry condition shall not flame or smolder for a distance of more than 12 inches (300 mm) from where a lighted cigarette is placed on the surface.

**806.90.2.3 Staples.** Staples for plastic netting or excelsior blanket shall be of No. 11 gage (3 mm diameter) or heavier, ungalvanized steel wire, "U" shaped, with approximately a 1 inch (25 mm) or larger crown and have a length of not less than 6 inches (150 mm).

**806.90.2.4** The contractor shall furnish a manufacturer's certification in triplicate stating the material furnished complies with the requirements of these specifications.

### **806.90.3 Construction Requirements.**

**806.90.3.1 Plastic Netting.** The area to be covered shall be seeded, fertilized and mulched in accordance with the requirements of the contract before the plastic netting is installed. The netting shall be rolled loosely over the specified areas as soon as practicable following the mulching operation. The netting shall be installed 28 feet (8.5 m) wide in median ditches and 1 foot (300 mm) above the flowline on other ditches. Lifting and stretching of the material will not be permitted. Any mulched areas disturbed by the installation of the netting shall be repaired at the contractor's expense. Rolling will not be required. Material shall overlap not less than 3 inches (75 mm) at all joints with the upper or upstream netting on top. All joints shall be stapled on 1-foot (300 mm) centers. Staples at other locations shall be installed as shown on the plans. If excelsior blanket is used in lieu of plastic netting, it shall be installed as specified in [Sec 806.90.3.2](#).

**806.90.3.2 Excelsior Blanket.** The area to be covered shall be seeded and fertilized in accordance with the requirements of the contract before the excelsior blanket is installed. The blanket shall be unrolled in the direction of water flow, with the netting on top and the fibers in contact with the soil. A longitudinal joint of adjoining blankets shall not be placed on the centerline of the ditch. The blanket shall not be stretched or pulled tight. Successive rolls shall be snugly butted at ends and edges. The blanket shall be stapled along each edge and along the center of each blanket with staples at 6-foot (2 m) centers and across each end of each roll with four staples. The center row of staples shall be staggered 3 feet (1 m) from the edge staple spacing. A row of staples across the blanket, spaced at 6-inch (150 mm) centers and at right angles to the ditch line shall be placed within each 50 feet (15 m) on ditch grades of 4 percent or less and within each 25 feet (7.5 m) on ditch grades greater than 4 percent.

**806.90.4 Method of Measurement.** Measurement of blankets or netting will be made to the nearest square yard (square meter) of surface area covered by the completed net.

**806.90.5 Basis of Payment.** The accepted quantity of blanket or netting complete, accepted and in place will be paid for at the contract unit price per square yard (square meter) for each of the pay items included in the contract and will be full compensation for all labor, equipment and material to complete the described work. If excelsior blanket is used in lieu of netting and mulch, payment will be made at the unit price for the pay items in the contract for the respective items which the excelsior blanket replaces.

## SECTION 808

### PLANTING TREES, SHRUBS AND OTHER PLANTS

**808.1 Description.** This work shall consist of furnishing and planting material in the locations designated on the plans or established by the engineer.

#### **808.2 Material.**

##### **808.2.1 Plants.**

**808.2.1.1** Trees, shrubs and other plants shall be nursery stock and shall be true to type and name in accordance with the current edition of Standardized Plant Names published by the American Joint Committee on Horticultural Nomenclature. They shall have well developed branch systems and vigorous healthy root systems. All stock shall be well formed and the trunks of trees shall be uniform. They shall be free from insects, disease and defects such as knots, sun-scald, injuries, serious abrasions of the bark or objectionable disfigurements. Thin weak plants will not be accepted. All nursery stock shall qualify under the AAN Horticultural Standards of the current American Standard for Nursery Stock, ANSI Z 60.1. Substitution of plant stock or other material will not be permitted except by approval of the engineer.

**808.2.1.2** All measurements for height, spread, branching, caliber and root spread or ball size shall be as specified in the current AAN American Standard for Nursery Stock, ANSI Z 60.1, except as modified herein. For bare root trees, the minimum root spread in feet (millimeters) shall be equal to one foot (300 mm) for each inch (25 mm) caliber, plus one foot (300 mm), except that if the natural root spread does not meet this requirement, the plant may be accepted provided no roots have been cut. Pine and spruce trees shall be full to the base and have a ratio of approximately five height to three spread. All trees for which the number of branches are shown shall have not less than the number specified. A branch shall have a minimum length of 24 inches (600 mm). For trees and shrubs having a spread or base width specified, the spread or base width shall be measured not more than 10 inches (250 mm) from the ground line from tip to tip of branches in their natural position. The height of all plants shall be measured from the ground line to the tip of the uppermost branch.

**808.2.1.3** Inspection of nursery stock may be made at the nursery by the engineer. Approval of material on such inspection shall not be construed as an acceptance. Inspection and acceptance of plant material will be made only at the planting site following the completion of the planting work with the exception that acceptance for height, spread and number of branches will be made before pruning the plant. Each shipment shall be accompanied by an invoice showing sizes and varieties of material included.

**808.2.1.4** All plant stock shall conform to the laws of Missouri and shall be certified free of insects and disease by the Department of Agriculture, Plant Industries Division.

**808.2.1.5** All stock shall be dug and packed with special care to avoid unnecessary injury to or removal of roots. Each variety shall be packed in separate bundles. Each bundle shall be clearly and accurately labeled. Roots shall be carefully protected with wet straw, moss or other material so that the plants arrive with roots in a moist and healthy condition.

**808.2.1.6** Plants specified by ball diameter shall be balled and burlapped and shall be lifted from the ground so as to retain as many roots as possible. Such plants shall be so dug and

transported as to provide and retain a firm ball of the original soil. The ball shall be wrapped with burlap and securely tied to keep the ball firm and intact. Balls shall be adequately protected from rain or sudden changes in weather. Trees or other plants will not be accepted if the balls of earth are loosened or broken.

**808.2.1.7** Plants specified as container grown shall have grown in that container sufficiently long for new fibrous roots to have developed so that the root mass will retain its shape and hold together when removed from the containers, however, it shall not have grown in the container long enough to have become pot bound. The container shall be sufficiently rigid to hold the ball shape protecting the root mass during shipping. The containers of all container grown plants, except Crown Vetch, shall be removed just prior to planting.

**808.2.2 Mulching Material.** The mulching material shall be wood chips substantially free of foreign material.

**808.2.3 Tree Wrapping Paper and Binder Twine.** Wrapping paper for trees shall be a waterproofed tree wrapping paper of good commercial quality furnished in 4-inch (100 mm) width. Twine for tying paper shall be any approved commercially available binder twine.

**808.2.4 Supporting Posts for Trees.** Supporting posts for evergreen trees shall be of approved "U", "Y", "T" or channel section steel posts, not less than 5 feet (1.5 m) long. Posts may be furnished plain, galvanized or painted, with or without base anchor plates. Supporting lumber for deciduous trees shall be of sound wood and free from knots that would affect the serviceability of the posts.

**808.2.5 Peat Moss.** Peat moss shall be the partially decomposed stems and leaves of any variety of sphagnum mosses and shall be substantially free of woody substances and mineral matter such as sulfur and iron. Peat moss shall be granulated and used in an air-dry, loose condition.

**808.2.6 Compost.** The material shall be produced from decayed organic yard waste. Yard waste may include leaves, grass clippings, tree limbs, Christmas trees and other yard and garden vegetation. The material shall have gone through a decomposition process from a compost site approved by the engineer and shall have decomposed to the point that it no longer resembles the individual components from which it was derived. The compost shall be dark brown to black in color.

### **808.3 Construction Requirements.**

**808.3.1 Planting Dates.** Planting shall be performed during either the fall phase or the spring phase or both, as specified in the contract. The beginning dates specified in the contract for the respective phases shall be considered to be the effective date of the Notice to Proceed.

**808.3.2** On highways open to traffic, the contractor shall avoid crossing the pavement with personnel, equipment or material. On divided highways, the contractor shall not cross the median with equipment, except at interchanges or established public median openings.

**808.3.3 Care of Plants Before and During Planting.** Immediately following delivery and inspection at the job site, all bare root plants shall be "heeled in" in a manner satisfactory to the engineer. All "heeled in", balled and burlapped, and container grown plants shall be protected and their roots kept moist until planted. While bare root plants are being transported to and from "heeling in" grounds, distributed in planting beds or awaiting planting after distribution, their roots shall be protected from drying out by means of wet canvas, burlap or straw, except as specified in [Sec 808.3.6.6](#). The trunks and branches of all trees shall be

carefully protected from injury of any kind during all operations. Any injured tree may be rejected.

**808.3.4 Location and Spacing of Plants.** The general location of each individual tree or shrub and the areas for ground cover plants will be shown on the plans. To facilitate the staking operations, the contractor shall notify the engineer in writing at least two weeks in advance of the date on which the contractor intends to begin planting. Stakes for indicating plant locations shall be furnished by the contractor in accordance with the requirements of [Sec 105.8](#).

**808.3.5 Pruning Roots.** A maximum of root growth shall be preserved and no root pruning will be permitted except as specified herein. Any large or fleshy roots that have been broken, crushed or badly bruised shall be cleanly cut back to sound wood. Interfering roots shall be pruned if directed by the engineer.

#### **808.3.6 Planting.**

**808.3.6.1** The planting of all plants shall be subject to the inspection of the engineer.

**808.3.6.2 Preparation of Holes.** Holes for trees shall be not less than 18 inches (450 mm) larger in diameter than the ball diameter, container or root spread. Holes for shrubs shall be not less than 12 inches (300 mm) larger than the ball diameter, container or root spread. Holes for vines and seedlings shall be not less than 9 inches (225 mm) in diameter. The holes shall be of such depth to set the plants at the same height they grew in the nursery. If the holes are dug too deep it shall be necessary to add enough backfill material to the bottom of the hole to allow for settling. Depth of holes for vines and seedlings shall be sufficient to allow for proper spreading of the roots.

**808.3.6.3 Backfill Material.** In general, backfill material for planting shall consist of the existing excavated soil broken into clods less than one inch (25 mm) in size and thoroughly mixed with peat moss or compost as required. Plants with a ball diameter, container or root spread of 15 inches (375 mm) or less require one bushel (0.035 m<sup>3</sup>) of peat moss or compost. Plants with a ball diameter, container or root spread of over 15 inches (375 mm) require two bushels (0.070 m<sup>3</sup>) of peat moss or compost. Peat moss or compost will not be required for vines or seedlings.

**808.3.6.4 Bare Root Trees and Shrubs.** Plants with bare roots shall be held firmly in the proper position with the roots spread out during backfilling. Backfill material shall be worked and puddled around the roots and thoroughly firmed during backfilling. Sufficient water shall be used to ensure thorough saturation of the backfill material around the plant roots.

**808.3.6.5 Balled and Burlapped and Container Grown Stock.** Plants which are balled and burlapped or container grown shall be set to proper position and grade. The backfill material shall be carefully worked and puddled around the ball. Sufficient water shall be used to ensure thorough saturation of the backfill material.

**808.3.6.6 Vines and Seedlings.** Vines and seedlings shall be planted on 3-foot (1 m) centers and 3-foot (1 m) staggered rows within specified areas. When a bundle of plants is opened, all plants in that bundle shall immediately be placed in a container of water and each plant planted from the container. Plants placed in the holes shall be backfilled immediately. Backfill material shall be thoroughly firmed, and all plants shall be watered the same day of planting.



**808.3.6.7 Preparation of Plant Beds.** Prior to planting in areas shown on the plans as plant beds, the existing sod shall be removed by stripping with a sod cutter set for a one-inch (25 mm) depth of cut. The sod so removed shall be disposed of by the contractor outside the limits of the right of way or as directed by the engineer.

**808.3.6.8 Mulching.** Individual plants, except for vines and seedlings, shall be mulched with a 4-inch (100 mm) thick layer of wood chips over the backfill or as shown on the plans. All areas shown on the plans as plant beds shall be mulched with a 4-inch (100 mm) thick layer of wood chips in a continuous bed over the entire area. Mulch will not be required for vines or seedlings.

#### **808.3.7 Pruning Branches or Stems.**

**808.3.7.1** Deciduous trees shall be pruned to balance the loss of roots. Pruning shall retain the natural form of the plant type. Only thinning cuts will be permitted on trees. A single trunk shall be preserved on all shade trees. All dead, broken and interfering branches shall be removed. When branches are removed, they shall be cut off flush with the parent branch. All cut surfaces over one inch (25 mm) in diameter shall be painted with tree paint or tar.

**808.3.7.2** Deciduous shrubs shall be pruned by removing all dead wood and broken branches and by removing or heading approximately 1/3 to 1/2 of the branches.

**808.3.7.3** Evergreens shall be pruned only to the extent of removing dead or damaged portions of the branches, except as permitted by the engineer.

**808.3.7.4** Vines shall be pruned to the extent necessary to retain approximately 6 inches (150 mm) of runner above the ground surface.

**808.3.8 Wrapping Trees.** The trunks of all deciduous trees and the lower part of the largest branches of trees more than 5-inch (125 mm) caliber shall be carefully wrapped with tree wrapping paper immediately after planting. The wrapping shall begin at the ground line and extend upward in a spiral to the lowest major branch. The spiral paper shall overlap not less than one inch (25 mm). Multiple stemmed trees shall have each stem separately wrapped to the lowest major branch. Suckers and small twigs shall be removed to permit proper wrapping. The wrapping paper shall be held in place with binder twine.

**808.3.9 Supporting Methods for Trees.** Deciduous trees, 3-inch (75 mm) caliber or larger, and evergreen trees, 3 feet (1 m) or more in height, shall be supported as shown on the plans. Supports shall be installed within two days of planting.

**808.3.10 Finishing.** Waste material, including sod, subsoil, rock, branches, twigs, packing material and other debris shall be disposed of by the contractor outside the limits of the right of way or as directed by the engineer. All roadway shoulders and other areas damaged by the contractor's operations shall be restored to a satisfactory condition as directed by the engineer. Finishing in accordance with this section shall be performed following the completion of each planting phase when fall and spring planting phases are required.

#### **808.4 Care and Replacement.**

**808.4.1** Starting with the first day of planting for each phase and continuing through a period of 45 days following the last day of planting within the respective phase, the contractor shall keep all plants watered sufficiently to maintain moist soil in the root zone. The engineer may specify watering as necessary to maintain moist soil and may halt further planting within the respective phases until sufficient water is applied to those plants in place. In addition to

watering, the contractor shall perform such weeding, adjusting tree supporting posts, pruning, chemical spraying for insect and disease control, and keep all bedded areas substantially clear of weeds and grass to ensure healthy plants. The contractor, at no cost to the Commission, will be permitted to apply commercial wilt proofing compound or liquid fertilizer on plants during the planting or the watering period of the contract.

**808.4.1.1** In addition to the 10 percent retained percentage specified in [Sec 808.6](#), there will be withheld an amount equal to 15 percent of the contract price for plants until satisfactory completion of the watering requirements specified for each phase of planting, at which time the 15 percent will be released.

**808.4.2** The contractor shall be responsible for the proper care of all plants until final inspection and acceptance of the plants has been made by the engineer.

**808.4.2.1** Any plant which, in the judgment of the engineer, is not in a healthy growing condition at the time of final plant inspection shall be replaced by the contractor in accordance with the original specifications, except that additional peat moss will not be required for the backfill material and that the specified 45-day watering period will not be required. No maintenance will be required for those plants replaced under this replacement specification.

**808.4.3 Final Plant Inspection.** For those contracts specifying fall phase planting only, the final inspection of plants will be made as soon as practicable after May 15. For those contracts specifying spring phase planting only, or specifying both fall and spring phase planting, the final plant inspection will be made as soon as practicable following either the specified spring watering period or May 15, whichever comes last. Plants not accepted at the time of final plant inspection will be marked and shall be replaced in the fall in accordance with the dates specified in the contract. The contractor will be relieved of all further responsibility for plants that are accepted at the time of final plant inspection.

**808.5 Liquidated Damages.** Liquidated damages will be charged in accordance with [Sec 108.8](#), except that liquidated damages will be charged against the contractor only for those days which would qualify as working days. The specified amount will be charged separately for each phase of planting and for the plant replacement period. Liquidated damages will not be charged during required watering periods.

**808.6 Method of Payment.** [Sec 109.7.3](#) is not applicable for this work. From the total amount of work items and material allowances of each biweekly estimate, there will be deducted 10 percent to be retained until released as provided in [Sec 109.9](#). The net amount due on the estimate will be certified to the Commission for payment.

**808.7 Basis of Payment.** The accepted quantities of plants will be paid for at the contract unit price for each plant of the types, species and sizes required, complete in place. No direct payment will be made for any incidental items such as supporting posts, mulch, peat moss, edging and water necessary for this work.

# **DIVISION 900**

## ***TRAFFIC CONTROL FACILITIES***



## SECTION 901

### HIGHWAY LIGHTING

**901.1 Description.** This work shall consist of furnishing and installing highway or street lighting equipment and material as shown on the plans.

**901.2 General.** Existing highway or street lighting shall be maintained in effective operation by the contractor except for shutdowns approved by the engineer for alterations or final removal.

**901.2.1 Temporary Lighting.** Temporary lighting shall consist of furnishing, installing and maintaining wood poles, luminaires, bracket arms, power cable, connection to a power source, mounting hardware and all other material necessary to provide the temporary installation. Any Commission furnished items shall be installed by the contractor. Temporary lighting specified as part of a temporary signal installation shall be installed on the signal poles unless otherwise shown on the plans.

**901.2.1.1** Luminaires shall be 150 watt high pressure sodium with a Type M-S-III light distribution and mounted at 30 feet (9 m) above the pavement unless otherwise shown on the plans. Bracket arms shall be a minimum of 10 feet (3 m) and a maximum of 15 feet (4.5 m) long and oriented at right angles to traffic flow unless otherwise shown on the plans. Photoelectric controls shall be provided and may be installed in the luminaires or in a separate control box at the option of the contractor unless otherwise shown on the plans. Any existing lighting shall not be taken out of operation until the temporary lighting is ready for operation and approved by the engineer. All temporary lighting equipment shall be removed by the contractor after the new installation is in operation or when ordered by the engineer. Contractor furnished equipment which shall remain the property of the contractor may be new or used. Contractor furnished equipment which shall become the property of the Commission shall be new. Commission owned equipment shall remain the property of the Commission and shall be disposed of as shown on the plans or as directed by the engineer.

**901.2.1.2** The contractor shall pay all electrical costs incurred by operation of the temporary lighting until the lighting is removed or until the lighting is accepted for maintenance. For temporary lighting installations where there is no existing power supply, it is the responsibility of the contractor to make any necessary arrangements for providing power to the temporary lighting. Portable generators may be used to provide power to temporary lighting, but any failure of the lighting system due to generator failure shall be considered a malfunction as specified in [Sec 901.5.7.2](#). No direct payment will be made for power costs. All wire and cable for temporary lighting shall be suspended overhead with proper clearance or buried a minimum of 18 inches (450 mm) underground.

**901.2.1.3** Temporary lighting installations shall be installed to meet the construction schedule. The contractor shall be responsible for maintaining the lighting in proper operating condition. Maintenance of temporary lighting shall meet requirements of [Sec 901.5.7.2](#). Any damage to the lighting installation from any cause whatsoever shall be repaired by the contractor at their expense.

**901.3 Material.** All material shall conform to Division 1000, Material Details, and specifically as follows:

Item	Section
Concrete	<a href="#">501</a>
Galvanized Coating of Steel Lighting Poles and Appurtenances	<a href="#">712</a>
High-Standard Bolts, Nuts and Washers	<a href="#">712</a>
Low-Carbon Steel Bolts, Nuts and Washers	<a href="#">712</a>
Reinforcing Steel for Concrete	<a href="#">1036</a>
Wood Poles for Power Supplies and Temporary Installation	<a href="#">1050</a>
Electrical Conduit	<a href="#">1060</a>
Electrical Conductors	<a href="#">1061</a>
Pull and Junction Boxes	<a href="#">1062</a>
<b>Specification</b>	
High-Strength Anchor Bolts	ASTM A 449
Low-Carbon Steel Anchor Bolts	ASTM A 307
Stainless Steel Bolts, Screws and Washers	ASTM A 193, Grades B5, B6, B7 or B16
Stainless Steel Nuts	ASTM A 194
Circular Steel Pile Foundation	ASTM A 252, Grade 2
Steel H-Pipe Foundation	AASHTO M 183
Screw Anchor Foundation	
Shaft	ASTM A 252, Grade 2
Helix	ASTM A 575, Grade M 1010
Helix Core	ASTM A 575, Grade M 1023
Connector Plates and Steel Closure Plates for Circular Pipes and Connector Plates for H-Pile and Screw Anchor Foundations	AASHTO M 183

**901.3.1** Bolts, nuts and washers specified to be galvanized shall be galvanized in accordance with the requirements of AASHTO M 232 (ASTM A 153), Class C, or mechanically galvanized in accordance with the requirements of AASHTO M 298 (ASTM B 695) Class 55. Galvanizing thickness shall not exceed 6 mils (150 µm). For high strength bolts, the contractor shall furnish to the engineer a copy of the manufacturer's inspection test report for each production lot or shipping lot furnished and shall certify that the bolts furnished conform to the requirements specified.

**901.3.2** Concrete shall be of the class specified in the contract. Material, proportioning, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#) for the specific class specified. Concrete shall be placed, finished and cured in accordance with the applicable provisions of [Sec 703](#).

**901.3.3** Equipment and material shall be of new stock unless the contract provides for relocation of existing units or use of units furnished by others. New equipment and material shall be the product of reputable manufacturers, conform to the requirements of ICEA, NEMA, NESC and the regulations of the National Board of Fire Underwriters, as applicable, and meet the approval of the engineer. A list of pre-approved equipment and material is available through the Division Engineer, Traffic.

**901.3.4** The configuration and installation of equipment mounted on substation and service poles shall meet the requirements of the utility company or municipality furnishing electrical power.

**901.3.5** Three copies of the list of equipment and material to be installed will be furnished to the successful bidder, along with the contract for execution. The contractor shall complete the list by writing in the name of the equipment manufacturer and catalog number of each item listed. Two copies of the completed list shall be submitted to the engineer and be approved in writing before the items are installed. Approval of the items on the list does not relieve the contractor of responsibility for satisfactory performance of the installation.

#### **901.4 Equipment.**

**901.4.1 Lighting Poles.** Lighting poles shall be steel or aluminum meeting the requirements of the contract and shall be of the same material and design throughout the project. The poles shall be Type AT, Type B or Type MB as shown on the plans. The contractor has the option to furnish poles with other shapes, gages and dimensions meeting or exceeding those shown on the plans and specifications. Shop drawings reflecting design and stress details of the poles or supporting bases shall be submitted to the engineer and be approved in writing prior to installation. The mounting height of the slipfitter above the pavement and the pole design numbers will be specified by numbers following the pole type designation. The contractor shall furnish the length of pole and bracket rise shown on the plans. Clamps shall be provided for connecting bracket arms to poles to obtain the specified mounting height. The cable entrance at the bracket arm shall be a field drilled 1 1/4 inch (32 mm) hole. The edges of the hole in steel poles shall be deburred and coated with commercially available inorganic zinc-rich paint. All cable entrance holes shall be fitted with a suitable rubber grommet. All handhole covers and pole caps shall be attached to the pole with a chain constructed of the same material as the pole. The chain shall be welded to the inside of the pole and of sufficient length to allow removal of the cover or cap for maintenance access. Shims may be used between the pole base or transformer base and the foundation for leveling purposes.

(a) Each Type AT pole shall have a wiring handhole with a suitable cover in the transformer base. Poles shall have removable raintight metal pole caps. The caps shall be held in place by screws. A grounding conductor shall be attached to the ground lug in each pole as shown on the plans. The grounding conductor shall provide grounding continuity for all metallic, noncurrent carrying poles in one circuit. The grounding conductor shall be securely connected to the grounding electrode on the supply side at the main disconnect switch.

(b) Each Type B and MB pole shall have a wiring handhole with a suitable metal cover near the base using two screws for attachment, a grounding lug for attaching a grounding conductor inside the pole convenient to the handhole and a removable raintight metal pole cap. The grounding conductor shall provide grounding continuity for all metallic, noncurrent carrying poles in one circuit.

**901.4.1.1** Steel lighting poles shall be round or octagonal shaft poles. The shaft section shall be fabricated from one length of basic oxygen or open hearth steel sheet, No. 11 gage (3.1 mm). The sheet shall be formed into a tube with one continuous welded longitudinal seam. After manufacture the material shall have a minimum yield strength of 48,000 pounds per square inch (330 MPa) including the weld. Shoe base type poles shall be manufactured with steel shoe bases or base plates attached to the lower end of the shafts. Each shoe base shall be a one piece casting conforming to AASHTO M 103, Grade 65-35, with four anchor bolt holes. It shall be equipped with four cast steel or cast iron bolt covers conforming to

AASHTO M 103 or M 105 and shall have four galvanized or stainless steel screws for securing covers to the shoe base. Each shoe base shall consist of a collar, flange and gussets, all integrally cast. Ample fillet radii shall be provided at the juncture of these components to reduce the effects of stress concentration. The flange of the base shall be flat and continuous around the outside of the collar. The base shall telescope the shaft and be secured by two continuous welds. One weld shall be on the inside of the base at the end of the shaft. The other weld shall be on the outside at the top of the base. The shoe base shall be arranged for bolting to a transformer base or to a foundation. Poles, shoe bases, base plates and covers shall be hot-dip galvanized inside and out after fabrication. The base plate shall be not less than 13 inches (330 mm) square, not less than 1 1/4 inches (32 mm) thick and fabricated from steel conforming to AASHTO M 223 having a yield strength of not less than 50,000 psi (345 MPa). It shall be arranged for bolting to a transformer base or to a foundation. It shall be equipped with four cast steel or cast iron bolt covers conforming to AASHTO M 103 or M 105 and shall have four galvanized or stainless steel screws for securing covers to the pole. Electrodes, weld profiles, quality of weld and minimum size of fillet welds shall meet the requirements of the latest edition of the AWS Structural Welding Code D1.1 - Steel.

**901.4.1.2** Aluminum lighting poles shall be round shaft poles. Each shaft shall be manufactured by the spun drawn method from seamless extruded aluminum tubing, ASTM B 221, Alloy 6063-T6 and shall have a nominal wall thickness for the lower section of 0.250 inch (6 mm) and a nominal wall thickness for the upper section of 0.188 inch (4.75 mm). The one piece shaft for 30-foot (9 m) mounting height shall have a nominal wall thickness of 0.188 inch (4.75 mm), except those with twin truss type arms shall have a nominal wall thickness of 0.250 inch (6 mm). Shoe base type poles shall be manufactured with heavy cast aluminum shoe bases attached to the lower ends of the shafts. Each shoe base shall be a permanent mold casting conforming to ASTM B 108, Alloy 356.0-T6 and shall be free from cracks, pits and blow holes. The shoe base shall be arranged for bolting to a transformer base or to a foundation. The base shall have four anchor bolt holes, shall be equipped with four cast aluminum bolt covers and shall have four stainless steel fasteners for securing covers to the shoe base. Each shoe base shall consist of a collar, flange and gussets, all integrally cast. Ample fillet radii shall be provided at the juncture of these components to reduce the effects of stress concentration. The flange of the base shall be flat and continuous completely around the outside of the collar. The base shall telescope the shaft and be secured by two continuous welds. One weld shall be on the inside of the base at the end of the shaft. The other weld shall be on the outside at the top of the base. The base and shaft shall be welded in the T4 temper with filler alloy 4043 and precipitation heat treated (artificially aged) to the T6 temper by an approved method after welding. Welding shall meet the applicable requirements of Section 5, Paragraph 1.5.3 of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

**901.4.1.2.1** At the contractor's option, the shafts for aluminum lighting poles may be formed from one piece of aluminum sheet, ASTM B 209, Alloy 5086-H34, having one continuous weld. The one-piece shaft for the 30-foot (9 m) mounting height shall have a 9-inch (230 mm) diameter at the base and a nominal wall thickness of 0.135 inch (3.5 mm). Shafts for 35 to 55-foot (10 to 17 m) mounting heights shall have a 13.4-inch (340 mm) diameter at the base and a nominal wall thickness of 0.135 inch (3.5 mm) for both sections. Each shoe base shall be a permanent mold casting having an integral cast aluminum riser and shall conform to ASTM B 108, Alloy 356.0-T6 and shall be free from cracks, pits and blow holes. The integral riser shall be designed to slip-fit into the pole shaft a sufficient distance to develop the full strength of the pole. The riser shall be bonded to the shaft with a structural epoxy adhesive that shall develop the strength of the pole. The epoxy shall develop a minimum of 1200 pounds per square inch (8 MPa) in shear, when tested in accordance with ASTM D 1002. The shoe base shall have four anchor bolt holes, shall be equipped with four cast aluminum bolt covers and shall have four stainless steel fasteners for securing the covers to the shoe base. Each shoe



base shall consist of a collar, flange and gussets, all integrally cast. The flange of the shoe base shall be flat.

**901.4.1.3** Transformer bases shall be permanent mold castings conforming to ASTM B 108, Alloy 356.0-T6 and shall be free from cracks, pits and blow holes. The transformer base shall be designed to accommodate and provide access to electrical equipment. It shall have internal lugs for mounting on a foundation and shall be designed for bolting to the base plate of the lighting pole using flat and lock washers in accordance with the plans. A grounding lug shall be provided in each base. The access opening shall have a hinged fiberglass or plastic door with a tamper resistant fastening device. The outside of the door shall be imprinted or adequately labeled with the warning, "DANGER - HIGH VOLTAGE". No direct payment will be made for transformer bases.

**901.4.1.4** Circular steel pile foundations for steel or aluminum lighting poles shall be of the dimensions shown on the plans and shall meet the requirements of ASTM A 252, Grade 2. The slotted hole may be saw or flame cut. If flame cut, the edges shall be ground smooth. The steel connector plate and steel closure plate shall be of the dimensions shown on the plans, welded to the steel pile foundation and shall conform to the requirements of AASHTO M 183. The foundation assembly shall be hot-dip galvanized inside and out after fabrication. Bolts shall project not less than 1/4 inch (6 mm) nor more than 5/8 inch (16 mm) beyond the nut when properly tensioned. Flat and lock washers shall be used for attachment.

**901.4.1.5** Steel H-pile foundations for steel or aluminum lighting poles shall be of the dimensions shown on the plans and shall meet the requirements of AASHTO M 183. The steel connector plates shall be of the dimensions shown on the plans, welded to the H-pile foundation and shall conform to the requirements of AASHTO M 183. The foundation assembly shall be hot-dip galvanized after fabrication. Bolts shall project not less than 1/4 inch (6 mm) nor more than 5/8 inch (16 mm) beyond the nut when properly tensioned. Flat and lock washers shall be used for attachment.

**901.4.1.6** Screw anchor foundations for steel or aluminum lighting poles shall be of the dimensions shown on the plans and shall conform to the ASTM designations shown. The slotted hole may be saw or flame cut. All sharp edges shall be ground smooth. The steel connector plates shall be of the dimensions shown on the plans, welded to the screw anchor shaft and shall conform to the requirements of AASHTO M 183. The foundation assembly shall be hot-dip galvanized inside and out after fabrication. Fabricator's shop drawings of the screw anchor foundations shall be provided. The shop drawings shall indicate the maximum torque rating of the foundations. Bolts shall project not less than 1/4 inch (6 mm) nor more than 5/8 inch (16 mm) beyond the nut when properly tensioned. Flat and lock washers shall be used for attachment.

**901.4.2 Bracket Arms.** Bracket arms shall be similar in design to those shown on the plans, shall be arranged for 2-inch (50 mm) slipfitter luminaire mounting and shall be attached to the poles as shown on the plans. Bracket arms shall be of the same kind of material as the pole on which they are mounted. Bracket arm mounting plates shall match the shape of the pole on which they are mounted. A 1-inch (25 mm) pipe nipple shall be welded in place in the wire entrance hole on the mounting plate. The welds shall be placed on the side of the plate away from the pole. Attachment bolts and nuts shall be properly tensioned. Flat and lock washers shall be used for attachment.

#### **901.4.3 Luminaires.**

**901.4.3.1 High Pressure Sodium.** High pressure sodium luminaires for roadway lighting shall be of the enclosed type with lamps burning in a horizontal position and for the type of

circuit specified. Type M-S-III, light distribution shall be set in accordance with the manufacturer's instructions unless otherwise directed by the engineer or shown on the plans. Each luminaire shall have an aluminum housing with two 2-inch (50 mm) slipfitters or one 4-bolt slipfitter and an internal ballast kit designed for that fixture. The housing shall have a natural aluminum or gray baked enamel finish. Reflectors shall have an alzak aluminum finish with reverse flange. The refractor shall consist of prismatic heat resistant glass in a cast aluminum holder. Plastic refractors shall not be used. The holder shall be secured to the luminaire by means of a hinge and an automatic latch. All metal parts, such as springs on the latches and hinges, U-bolts and screws shall be made from non-ferrous metal or stainless steel. All parts of the luminaire shall be fabricated from corrosion resistant material. Lamp size shall be as specified in the contract. Lamps shall have a rated life of not less than 20,000 hours for 400-watt, 15,000 hours for 250-watt and 12,000 hours for 150-watt lamps based on ten hours per start. Wiring inside the luminaire housing shall be protected by suitable heat resistant insulating material. The reflector-refractor optical assembly and the ballast shall form a single unit. The optical system (reflector, bottom refractor, lamp socket and lamp) shall be a sealed chamber with provision for filtered ventilation. Ventilation shall permit intake and exit of air into or from the chamber as a result of expansion or contraction of air in the chamber due to lamp heat. Filtering shall be accomplished by either a separate filter or a filtering gasket. The ballast shall be pre-wired to the lamp socket and to a terminal board so that only the connection of the supply leads to the ballast primary terminals is necessary. A pipe stop shall be included in the assembly to locate the luminaire properly on the bracket arm. Ballasts shall be of the regulator type and shall operate satisfactorily throughout a voltage range of plus or minus ten percent of their nominal primary voltage rating. The change in lamp wattage over this range shall not exceed that recommended by the manufacturer. The ballast shall start and operate the lamp satisfactorily to a minimum temperature of -20 F (-28C). The ballast shall have a power factor of not less than 90 percent.

**901.4.3.2 Underpass.** Luminaires for underpass lighting shall be high pressure sodium. The luminaires shall consist of a pre-wired unit for wall mounting, with raintight cast aluminum housing, cast aluminum door with integral cast guard, heat-resistant glass prismatic refractor, asymmetric aluminum reflector and socket for horizontal lamp position, complete with 150-watt lamp and 240-volt or 480-volt ballast as required. Type S-N-IV, light distribution shall be set in accordance with the manufacturer's instructions unless otherwise directed by the engineer or shown on the plans. The door shall have a stainless steel hinge along the bottom, stainless steel latches at the top and non-ferrous or stainless steel safety chains. Provisions shall be made for attaching the unit directly to a wall or to an outlet box stud with stainless steel hardware. Ballasts for underpass luminaires shall meet the applicable requirements of [Sec 901.4.3.1](#). The ballast power cables shall be individually fused with in-line fuse holders between the line and load in the junction box or the luminaire housing if no junction box is shown on the plans. The fuse rating shall be three amps unless otherwise shown on the plans.

**901.4.4 Control Stations.** Control stations shall consist of all equipment and material necessary for the distribution of secondary electrical power as shown on the plans. Control stations will be specified by the secondary voltage.

**901.4.4.1** Control cabinets shall have a control panel constructed of the same material as the cabinet. All equipment such as circuit breakers, switches, contactors, fuses, photoelectric control and terminal blocks shall be installed on the panel as shown on the plans. Control cabinets shall be of sufficient size to house all equipment as shown on the plans. Cabinets shall be dust-tight, watertight, NEMA 4 and constructed of 0.125 inch (3 mm) minimum reinforced sheet aluminum alloy and be of clean-cut design and appearance. All hinges, catches and other hardware shall be non-ferrous metal or stainless steel. Cabinets shall have a No. 2 Corbin cabinet lock and provisions for locking with a padlock. Two keys for cabinet locks shall be furnished by the contractor. Mounting shall be as shown on the plans.

**901.4.4.2** Lightning arrestors shall be of the rated voltage as shown on the plans.

**901.4.4.3** Photoelectric controls shall be of the cadmium-sulfide type or solid state type operating on 120 volts or 240 volts, as shown on the plans. They shall operate on a line supply of 50 to 60 hertz. The load capacity of the photoelectric cell relays shall be a minimum of 1000 watts. They shall operate a lighting system through mercury load relays or contactors as shown on the plans. The photoelectric cell circuitry shall be designed to be normally closed at night. The turn-on range shall be adjustable from 1.0 to 3.0 footcandles (10 to 32 lux). A turn-on setting of 1.0 footcandle (10 lux) and a turn-off setting of 2.0 footcandles (22 lux) shall be made at the factory. The relay shall have a time delay to avoid operation due to lightning and transient light. In the event of failure, the relay shall fail safe, that is, the lights are left on in the event of any failure in the electronic circuit. A suitable bracket for mounting to orient the photoelectric cell window toward the north sky and a lightning arrestor shall be included as part of the unit. The photoelectric cell shall be mounted into a three prong twist lock socket.

**901.4.4.4** Contactors shall be NEMA Type 1 enclosed, magnetic type, two pole, single phase for 600 volts, 60 hertz service. The operating coil shall be designed for 120-volt or 240-volt operation as shown on the plans. The contactor shall be electrically held and rated not less than that shown on the plans. Contactors shall be housed in the control cabinet as shown on the plans.

**901.4.4.4.1** At the option of the contractor, mercury load relays may be used in lieu of contactors. Mercury load relays shall be two pole, normally open, mercury contact, magnetic type with load capacity as shown on the plans.

**901.4.4.5** Test switches used with photoelectric controls shall be three position switches or two single pole breakers as shown on the plans. Test switches shall be mounted in the control cabinet and shall be clearly labeled.

**901.4.4.6 Circuit Breakers.** All circuit breakers shall be molded case thermal magnetic circuit breakers. The number and trip rating of circuit breakers shall be as shown on the plans. All breakers shall be designed for panel mounting with cable connections on the line and load sides.

**901.4.4.6.1 Type A Circuit Breakers.** Type A breakers shall have a minimum of 18,000 amps AC interrupting rating at 240 volts AC and 14,000 amps AC interrupting rating at 480 volts AC. Breakers shall be designed to accept wire sizes up to 4/0 (12 mm) with proper terminals. Terminals shall be provided for the wire sizes as shown on the plans.

**901.4.4.6.2 Type B Circuit Breakers.** Type B breakers shall have a minimum of 10,000 amps AC interrupting rating at 240 volts AC. Type B breakers shall have a nominal size no greater than 1 inch (25 mm) wide by 4 inches (100 mm) high by 3 inches (75 mm) deep. Terminals shall be configured for the wire sizes as shown on the plans. If the breaker terminals are not designed for the required wire sizes, suitable terminal adapters, connectors or terminal blocks shall be used to convert the wire sizes.

**901.4.5 Power Supply Assembly.** The power supply assembly shall consist of all equipment mounted on a service pole or pedestal as shown on the plans. The assembly shall meet the approval of the utility company. All contractor provided meter boxes and disconnect boxes shall be constructed of aluminum or stainless steel. All hinges, catches and other hardware shall be non-ferrous metal or stainless steel.

**901.4.5.1** Main disconnect switches shall be separately housed on the power supply. The disconnect cabinet shall be dust-tight, watertight, NEMA 4 and contain a Type A or Type B circuit breaker conforming to [Sec 901.4.4](#) of the rating shown on the plans. The operating handle shall have full cover interlock to prevent the door from opening when the breaker is on. The enclosure shall have provisions for padlocking both the enclosure and switch in the on or off position.

**901.4.5.2** Circuit breaker cabinets and meters shall not be installed on the street or walk side of the pole or pedestal.

**901.4.5.3** Meter boxes shall be NEMA 3R or NEMA 4. Meter sockets provided by the contractor shall be Underwriters Laboratories approved and conform to the requirements of the utility company or municipality providing power.

**901.4.5.4** Power supply poles shall consist of wood poles and crossarms, insulators, necessary pole line hardware, conduit, ground rods, guy wires and anchors and all other accessories and appurtenances mounted on the pole except those furnished by the utility company or municipality, or specified separately in the contract. Power supply pedestals shall consist of a W6 x 9 (W150 x 14) or W6 x 15 (W150 x 22) galvanized steel post, a concrete footing and all other accessories and appurtenances mounted on the post except those furnished by the utility company or municipality, or specified separately in the contract. The conduit attached to the power supply pole or pedestal and any necessary attachment hardware shall be included with the power supply and no direct payment will be made. The assembly shall meet the safety requirements and approval of the utility company or municipality furnishing power for operation.

## **901.5 Construction Requirements.**

**901.5.1 Rigid Conduit System.** Conduit shall be placed as shown on the plans. Rigid conduit shall be installed in accordance with the applicable requirements of [Sec 902.5.3](#).

### **901.5.2 Trenching and Backfilling.**

**901.5.2.1** Trenching and backfilling for conduit and cable-conduit shall be to not less than the depth shown on the plans. No conduit or cable-conduit shall be placed in a trench prior to inspection of the trench by the engineer. The contractor shall move, store and relay sod and shall furnish and place topsoil and sod at locations as directed by the engineer. Where excavation is made across parkways or driveways, the sod, topsoil and crushed stone or gravel shall be replaced as nearly as practicable to its former condition. Concrete or bituminous surfaces and stabilized bases shall be restored to their former condition. The entire area involved shall be left in a neat, presentable condition.

**901.5.2.2** Type I, 24 inch (600 mm) trenching for cable-conduit is specified if the excavated material would be classified as Class A Excavation, as defined in [Sec 203.1.1](#) and no material is in evidence which might cause mechanical damage to cable-conduit. The cable-conduit shall be laid on the bottom of the trench and the trench backfilled.

**901.5.2.2.1** In lieu of Type I, 24 inch (600 mm) trenching, the cable-conduit may be installed by plowing. When installation is accomplished by plowing it shall be done with a vibratory type plow which will place the cable-conduit at a minimum depth of 18 inches (450 mm) and recompact the soil over the installation approximately to original in-place density.

**901.5.2.3** Type II, 24 inch (600 mm) trenching for cable-conduit is specified if the excavated material would be classified as Class A Excavation, as defined in [Sec 203.1.1](#) and material is

in evidence which might cause mechanical damage to cable-conduit. Type II trenching will also include trenching in rock embankment. The cable-conduit shall be embedded in sand as shown on the plans and the trench backfilled.

**901.5.2.4** Type III, 21 inch (535 mm) trenching for cable-conduit is specified if material which would be classified as other than Class A Excavation, as defined in [Sec 203.1.1](#), is encountered. The cable-conduit shall be embedded in sand as shown on the plans and the trench backfilled.

**901.5.2.5** All trenches shall be backfilled as soon as practicable after the installation of conduit or cable-conduit. Cinders, broken concrete and other hard or objectionable material which might cause mechanical damage to conduit or cable-conduit shall not be used for backfilling to an elevation 12 inches (300 mm) above the top of conduit or cable-conduit. Backfill material shall be deposited in layers not exceeding 6 inches (150 mm) deep and each layer shall be compacted to the approximate density of the adjacent material by tamping or other approved methods before the next layer is placed in the trench. Red burial tape imprinted with "CAUTION - BURIED CABLE BELOW" shall be installed in all trenches at approximately 1/3 to 1/2 of the depth of the trench. If the trench is to be located under a shoulder which is to be stabilized, the trenching, installation of conduit or cable-conduit and backfilling the trench shall be completed before the shoulder stabilization construction is started. Unless the lighting poles are in place, a coil of cable or cable-conduit of sufficient length to reach the proposed handhole shall be buried near each pole location. The coil shall be covered with planks, a box or other approved means so that it will not be damaged.

### **901.5.3 Pull and Junction Boxes.**

**901.5.3.1** Only concrete pull boxes shall be placed in the traveled way, auxiliary lanes, shoulders and low profile islands.

**901.5.3.2** Conduit shall enter the pull box in the side of the box. If it is necessary to increase the excavation depth and extend the pull box, no direct payment will be made. The excavated opening outside the pull box shall be wide enough to allow compaction of the backfill material. Cinders, broken concrete, broken rock or other hard or undesirable material shall not be used for backfilling. The backfill material shall be placed in layers not to exceed 6 inches (150 mm) deep and each layer shall be thoroughly compacted before the next layer is placed. Where preformed pull boxes are used, the holes for the conduit shall be made as recommended by the manufacturer. The holes shall be round and no more than 1/2 inch (13 mm) larger than the conduit.

**901.5.3.3** Stone drains for pull boxes shall be constructed as shown on the plans.

**901.5.3.4** Pull boxes shall be installed at locations shown on the plans. A pull box placed in a sodded area or shoulder shall have a concrete pad as shown on the plans around the perimeter. Concrete pads are not required for pull boxes installed in concrete shoulders. Concrete for the pad shall be Class B, or a commercial mixture meeting the requirements of [Sec 501](#). The top surface of all pull boxes shall be flush with surfaced areas and approximately one inch (25 mm) above earth or sodded areas.

**901.5.3.5** Junction boxes shall be installed at locations shown on the plans. No direct payment will be made for junction boxes.

### **901.5.4 Pile Foundation and Installation.**

**901.5.4.1** Concrete foundations for ground mounted poles shall be of Class B concrete and shall have dimensions not less than shown on the plans. Forms will not be required for concrete placed below finished ground line. All conduits and anchor bolts shall be rigidly installed before the concrete is placed. All portions of the anchor bolts extending above the foundation shall be threaded. Anchor bolts shall be spaced by means of a template, the center of which shall coincide with the center of the base. Installation of poles on integral concrete median and foundation shall be to the dimensions and design shown on the plans.

**901.5.4.2** Steel circular and H-pile foundations for ground mounted poles shall be installed in a hole of the approximate dimensions shown on the plans and secured by tamped, wet limestone screenings. Steel pile foundations with poles attached may be installed as a unit. The steel connector plate shall be at the proper elevation and properly oriented to receive the transformer base. The connector plate shall be flush with the finished grade or surface and shall not extend above the finished grade on slopes.

**901.5.4.3** The minimum installing torque for screw anchor foundations shall be as shown on the plans and shall not exceed the maximum torque rating shown on the fabricator's shop drawings. The steel connector plate shall be at the proper elevation and properly oriented to receive the transformer base. The connector plate shall be flush with the finished grade or surface and shall not extend above the finished grade on slopes.

**901.5.4.4** Leveling and raking of poles on structures may be accomplished by use of shims, not to exceed a total of 1/2 inch (13 mm), on bolts. Where poles are to be placed on existing foundations or structures with anchor bolts in place, it shall be the contractor's responsibility to furnish poles with a base to fit the anchor bolt spacing.

**901.5.5 Luminaires.** Luminaires for roadway lighting shall be adjusted to give proper illumination on the roadway. Luminaires for underpass lighting shall be interconnected with 1-inch (25 mm) minimum rigid conduit unless other provisions are incorporated into the structure. Conduit shall conform to [Sec 902.5.3](#).

#### **901.5.6 Blank.**

**901.5.7 Circuits.** Circuits shall be properly labeled in all handholes, pull boxes and junction boxes by means of round aluminum identification tags with a minimum thickness of 0.1 mils (2.5  $\mu$ m) attached to the cables with copper wire. Prior to energizing any circuit, the insulation resistance to ground of each completed lighting circuit shall be tested and shall be not less than 10 M $\Omega$ . Any circuit less than 10 M $\Omega$  to ground will be rejected. The contractor shall provide a suitable 500-volt DC, zero to 100-M $\Omega$  range resistance measuring device for making the resistance test. Circuit test shall be performed by the contractor in the presence of the engineer and shall be documented.

**901.5.7.1** After the circuits have been tested and found acceptable, the contractor shall, upon concurrence of the engineer, energize the lighting circuits for a 15 consecutive day test period. All circuits being energized from a control station shall be tested as a system. The system shall be tested as a unit. Any malfunction on any circuit shall be corrected and the system tested for an additional 15 consecutive day period. This procedure shall be repeated until the lighting system has operated to the engineer's satisfaction for 15 consecutive days.

**901.5.7.2** When the test period is initiated and until it is completed, or following the turn-on of temporary lighting, the contractor shall provide at least one service technician to remain in the area and be available for day, night and weekend trouble calls. The contractor shall furnish the name, address and telephone number where each designated technician can be reached at all times. If the lighting system malfunctions and a designated technician cannot be

reached or cannot arrive at the location in a reasonable time in the judgment of the engineer, the engineer may exercise the option to direct MoDOT personnel or a third party to correct the malfunction. If this option is invoked, the entire cost of the work performed by MoDOT personnel or the third party will be deducted from the monies due the contractor. These costs will be computed as described in [Sec 108.9](#). Whether or not the engineer elects to correct the malfunction, nothing in this specification shall be construed or interpreted to relieve the contractor of any liability for personal injury or property damage that results either directly or indirectly from a malfunction during the test period. The contractor and surety shall indemnify and save harmless the State, the Commission, its agents, employees and assigns for any legal liability for such a malfunction.

#### **901.5.8 Installation of Cable and Cable-Conduit.**

**901.5.8.1** The cable-conduit combination shall be installed in a trench of the type specified. Cable-conduit runs shall be continuous without splice between control panel, handholes, pull boxes, poles and junction boxes. All conduit ends shall be sealed around the cables with an approved readily workable soft plastic sealing compound. The compound shall be workable at temperatures as low as 30 F (-1 C) and shall not melt or run at temperatures as high as 300 F (150 C). Cable-conduit shall be allowed to "snake" in the trench, but there shall be no sharp bends and if two or more assemblies are placed in a common trench, they shall not cross each other. Conduit, larger than the cable-conduit, shall be constructed in concrete foundations for bolt down poles and the cable-conduit installed through the conduit and out the handhole in the transformer base or pole. Cable-conduit shall extend a minimum of 18 inches (450 mm) above the top of the foundation. The conduit of the cable-conduit shall then be cut off circumferentially in the transformer base or pole, leaving the cables exposed for connection. Where placed under paved roadways, other paved areas and any type of shoulder, the cable-conduit shall be installed in rigid conduit. Standard commercial duct fittings shall be used to connect conduit of cable-conduit to rigid conduit at bridge ends and the cables shall continue without splice through the conduit to the nearest pole base. For underpass lighting or wall-mounted brackets, the cables shall continue unspliced to the nearest junction box or luminaire housing if junction boxes are not shown on the plans.

**901.5.8.2** The ground wire shall be attached to a ground lug at each lighting pole. If bolt down base poles are specified, the ground wire shall be attached to the ground lug in the pole base.

**901.5.8.3 Cable Splicing.** Splices shall be made only in pull boxes, junction boxes and pole bases. No more than four cables shall be spliced in above ground tee splices in pole bases and junction boxes immediately adjacent to wall mounted brackets or underpass luminaires. No more than three pairs of power cables shall be spliced at any other location. Straight or line splices shall only be made in pole bases and junction boxes immediately adjacent to underpass luminaires or wall mounted brackets unless otherwise approved by the engineer. Where junction boxes are not shown on the plans with underpass luminaires, splices may be made in the luminaire housing. Tee splices shall only be made at the locations shown on the plans.

**901.5.8.3.1** Line splicing in all types of poles, above ground junction boxes and luminaire housings shall be accomplished with a premolded fused connector assembly. Line splicing in all breakaway pole bases shall be accomplished with a premolded fused slip connector assembly as shown on the plans. After a conductor splice is made, it shall be insulated with a protective rubber boot designed for the premolded connector. All above ground tee splices shall be accomplished with a splice block with a moulded plastic insulating cover. The splice block shall be designed for the wire size used. The splice block shall have one port per wire and the wires shall be secured with set screws. The set screw holes shall be protected with removable plugs. Any required taping shall be accomplished with a rubber, pressure-

sensitive, all weather 30-mil (750 µm) splice tape. The tape shall be applied half-lap to a thickness equal to 1 1/2 times the thickness of the factory applied insulation and sheath and taper off over the sheath neatly to a point approximately 3 inches (75 mm) from the conductor splice. All sharp points and edges of the connector shall be padded and all voids filled with extra wraps of plastic tape. The tape shall not be stretched excessively nor in such manner as to cause creeping.

**901.5.8.3.2** Underground cable splices, if specified, shall be made in a pull box. Straight or line splices shall be made with copper-clad pressed sleeves or an approved equivalent. Tee splices shall be made with a pressed sleeve, split or unsplit type or an approved equivalent. All splices shall be protected with a resin splice kit installed in accordance with the manufacturer's recommendations. The resin splice kit shall consist of a protective plastic case designed for the type of connector used, filled with a resin insulating compound mixed in accordance with the manufacturer's recommendations.

**901.5.8.4** Cables shall be pulled through rigid conduit by a cable grip providing a firm hold on exterior coverings. Cable shall be pulled with a minimum of dragging on the ground or pavement. Frame mounted pulleys or other suitable devices shall be used for pulling cables out of conduits into pull boxes. Lubricants may be used to facilitate pulling cable. Slack in each cable shall be provided by a 6-foot (2 m) loop in each pull box. Where cable-conduit enters a pull box, 6 feet (2 m) of cable shall be coiled in the pull box. Where cable enters a junction box, 3 feet (1 m) of cable shall be coiled in the junction box.

**901.6 Maintenance Information.** Before acceptance of the work, the contractor shall furnish the engineer four copies of the manufacturers' instructions for maintenance and operation of all lighting equipment, wiring diagrams of the system and a parts list for the ordering of any parts.

**901.7 Final Clean Up.** Final cleaning up of right of way shall be in accordance with [Sec 104.9](#).

#### **901.8 Method of Measurement.**

**901.8.1** Measurement of trenching, including backfilling, except for rigid conduit, will be made to the nearest linear foot (0.5 m) along the centerline of the trench. No measurement of trenching will be made for rigid conduit.

**901.8.2** Measurement of rigid conduit will be made to the nearest linear foot (0.5 m) as shown on the plans. Contract quantities will be used in final payment except as hereinafter provided.

**901.8.3** Measurement of power cable, pole and bracket cable, multiconductor cable, wire and cable-conduit will be made to the nearest 10 linear feet (5 m) as shown on the plans. Contract quantities will be used in final payment except as hereinafter provided.

**901.8.4** Measurement of luminaires and bracket arms, including all required material and hardware, will be made per each as separate items.

**901.8.5** Measurement of Type AT poles and foundations, including all specified material, will be made per each as separate items.

**901.8.6** Measurement of Type MB poles, complete in place, will be made per each as a single item including footing and integral portion of median barrier. No direct payment will be made for footing or integral portion of median barrier for Type MB poles.



**901.8.7** Measurement of control stations, including all specified equipment, will be made per each.

**901.8.8** Measurement of power supply assemblies, including all specified equipment, will be made per each.

**901.8.9** Measurement of pull boxes, including all specified material, will be made per each.

**901.8.10** For those items on which final payment is based on contract quantities, final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from, the contract quantity.

**901.8.11** Measurement of temporary lighting installations will be made per lump sum.

**901.9 Basis of Payment.**

**901.9.1** Accepted highway lighting will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for any incidental items necessary to complete the work unless specifically provided as a pay item in the contract.

**901.9.2** If the contract does not contain a unit price for Type III Trenching and material which would be classified as other than Class A Excavation, as defined in [Sec 203.1.1](#), is encountered on construction, payment for such trenching will be made at a unit price of three times the contract unit price for Type II Trenching per linear foot (meter).

## SECTION 902

### TRAFFIC SIGNALS

**902.1 Description.** This work shall consist of furnishing and installing traffic signal equipment and material as shown on the plans.

**902.2 General.** Existing traffic signals shall be maintained in effective operation by the contractor except for shutdowns approved by the engineer for alterations or final removal. After any modifications have been made or after work is begun on an existing signal installation, the contractor shall maintain the signals in accordance with [Sec 902.5.9.1](#). The contractor shall notify local traffic control agencies prior to operational shutdown of any traffic signal. All traffic signal equipment which the contractor uses or installs on the project, whether furnished by the Commission or the contractor, either on a temporary or permanent basis, shall, upon installation or upon initial use by the contractor, be operated and maintained by the contractor until the project is completed and accepted. Any malfunction of an existing signal installation resulting from the contractor's operation, regardless of the nature of the work, shall be corrected at the contractor's expense in accordance with [Sec 902.5.9.1](#). If any adjustments are required to the operation of an existing signal installation due to the contractor's operation, the contractor shall provide a minimum of two working days notice to the engineer.

**902.2.1 Temporary Traffic Signals.** Temporary traffic signals shall consist of furnishing and installing poles for span wire, span and tether wires, control and power cable, connection to a power source, maintenance of the installation and all other equipment and material necessary to provide the temporary installation including the controller, signal heads and mounting hardware, unless Commission furnished. If the temporary traffic signal installation is not shown on the plans, the contractor shall submit a plan to the engineer for approval prior to the installation of temporary signals. Any existing or Commission furnished signal equipment to be used in the temporary signal shall be shown on the temporary signal plan. Temporary signals shall have the signal heads covered until they are placed in operation. A minimum of two signal faces, meeting the requirements of [Sec 902.4](#), shall be oriented toward each street approach positioned a minimum of 8 feet (2.5 m) apart center to center and a minimum of 16 feet (5 m) above the surface of the traveled way to the bottom of the backplate. Existing signals shall not be taken out of operation until the temporary signals are ready for operation and approved by the engineer. A flashing operation shall be used during shutdown of the temporary signals. All temporary signal equipment shall be removed by the contractor after the new installation is in operation or when ordered by the engineer. Contractor furnished equipment which shall remain the property of the contractor may be new or used. Contractor furnished equipment which shall become the property of the Commission shall be new. Commission owned equipment shall remain the property of the Commission and shall be disposed of as shown on the plans or as directed by the engineer.

**902.2.2** The contractor shall pay all electrical costs incurred by operation of the temporary signals and incurred by the new signal system until the signals are accepted for maintenance. For temporary signal installations where there is no existing signal power supply, it is the responsibility of the contractor to make any necessary arrangements for providing power to the temporary signals. Portable generators shall not be used to provide power to temporary signals. No direct payment will be made for power costs. All wire and cable for temporary signals shall be suspended overhead with proper clearance or buried a minimum of 18 inches (450 mm) underground.

**902.2.3** Temporary signal installations shall be installed to meet the construction schedule. The contractor shall provide a minimum of two working days notice to the engineer in advance of the signal turn-on. The contractor shall be responsible for maintaining the signals in proper operating condition. Maintenance of temporary traffic signals shall meet requirements of [Sec 902.5.9.1](#). Any damage to the traffic signal installation from any cause whatsoever shall be repaired at the contractor's expense.

**902.3 Material.** All material shall conform to Division 1000, Material Details, and specifically as follows:

Item	Section
Galvanized Coating of Traffic Signal Posts and Appurtenances	<a href="#">712</a>
High-Strength Bolts, Nuts and Washers	<a href="#">712</a>
Low-Carbon Steel Bolts, Nuts and Washers	<a href="#">712</a>
Structural Low Alloy Steel	<a href="#">712</a>
Stainless Steel Bolts, Screws and Washers	<a href="#">901</a>
Stainless Steel Nuts	<a href="#">901</a>
Reinforcing Steel for Concrete	<a href="#">1036</a>
Wood Poles for Power Supplies and Temporary Installations	<a href="#">1050</a>
Electrical Conduit	<a href="#">1060</a>
Electrical Conductors	<a href="#">1061</a>
Pull and Junction Boxes	<a href="#">1062</a>

**902.3.1** Bolts, nuts and washers specified to be galvanized shall be galvanized in accordance with the requirements of AASHTO M 232 (ASTM A 153), Class C or mechanically galvanized in accordance with the requirements of AASHTO M 298 (ASTM B 695), Class 55. Galvanizing thickness shall not exceed 6 mils (150 µm). Anchor bolts shall have a minimum yield strength of 55,000 pounds per square inch (380 MPa) and a minimum elongation of 14.0 percent in 2 inches (50 mm) or 12.0 percent in 8 inches (200 mm). Nuts for anchor bolts shall conform to ASTM A 563, Grade C, D or DH or ASTM A 194 Grade 2 or 2H. For anchor bolts and nuts and for high strength bolts and nuts except AASHTO M 164, the contractor shall furnish to the engineer a test report certified to be the last completed set of mechanical tests for each size in each shipment. For bolts specified to conform to AASHTO M 164, the contractor shall furnish to the engineer a copy of the manufacturer's inspection test report for each production lot or shipping lot furnished and shall certify that the bolts furnished conform to the requirements specified. Bolts and nuts specified to meet ASTM A 307 shall be accompanied by a manufacturer's statement that the bolts and nuts were manufactured to conform to ASTM A 307.

**902.3.2** Concrete shall be of the class specified in the contract. Material, proportioning, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#) for the specific class specified. Concrete shall be placed, finished and cured in accordance with applicable provisions of [Sec 703](#). The entire exposed surface, including sides and top, shall be surface sealed in accordance with the applicable requirements of [Sec 703.3.18](#).

**902.3.3** Equipment and material shall be of new stock unless the contract provides for relocation of existing units or use of units furnished by others. New equipment and material shall be the product of reputable manufacturers, conform to requirements of CALTRANS 170 Specifications, ICEA, IMSA, ITE, MUTCD, NEMA, RETMA, NEC and the regulations of the National Board of Fire Underwriters, as applicable, and meet the approval of the engineer. A list of pre-approved equipment and material is available through the Division Engineer, Traffic.

**902.3.4** The configuration and installation of equipment mounted on a utility company's poles shall meet requirements of the utility company.

**902.3.5** Three copies of the list of equipment and material to be installed will be furnished to the successful bidder, along with the contract for execution. The contractor shall complete the list by writing in the name of the equipment manufacturer and catalog number of each item listed. Two copies of the completed list shall be submitted to the engineer and be approved in writing before the items are installed. Approval of the items on the list does not relieve the contractor of responsibility for satisfactory performance of the installation. If telephone interconnection equipment is specified in the contract, the successful bidder will be furnished three copies of Form D-25 for execution as specified in [Sec 902.4.6.3.7](#).

#### **902.4 Equipment.**

**902.4.1 Signal Heads.** Each signal head of one or more signal faces shall be conventional or, if designated on the plans, optically limiting. The contractor has the option to furnish aluminum or polycarbonate signal heads. All signal heads shall be weatherproof and meet the following requirements:

(a) All signal heads shall be black in color in accordance with [Sec 902.5.10](#). All indications shall be 12 inches (300 mm) unless otherwise specified.

(b) All red signal indications in conventional signal heads shall be illuminated with light emitting diode (LED) modules. LED modules shall conform to ITE specifications and standards for LED vehicle traffic signal modules and the following:

(1) The lens of each indication shall be tinted with a wavelength-matched color to reduce sun phantom effect and enhance on/off contrast. The tinting shall be uniform across the lens face. If a polymeric lens is supplied, a surface coating shall be applied to provide abrasion resistance.

(2) LED modules shall not contain Aluminum Gallium Arsenide (AlGaAs) LEDs.

(3) LED modules shall provide constant light output under power. Modules with dimming capabilities shall have the option disabled or set on a non-dimming operation.

(4) In the event of a power outage, light output from the LED modules shall cease instantaneously.

(c) Incandescent signal indications in conventional and optically limiting signal heads and walk indications in pedestrian signal heads shall be certified by the manufacturer.

(d) Each signal face shall be furnished with a terminal block with circuit capacity as required but not less than four terminals. If single sections are specified, each section shall be furnished with a terminal block. All terminal blocks shall be rigidly secured to the section housing.

(e) A tunnel visor shall be supplied with each signal section unless otherwise specified.

(f) The position of signal indications shall be as specified in the contract.

(g) The lamp receptacle shall be designed so that it will be impossible for the lamp to loosen due to thermal expansion or vibration. The lamp receptacle shall be of heat resistant material and shall be of the fixed-focus type. The receptacle shall be designed to hold a 67, 100, 135 or 150-watt, Type A-21, traffic signal lamp with the light center at 2 7/16 inches (62 mm) for 8-inch (200 mm) diameter signals and to hold a medium screw base lamp having a 3-inch (75 mm) light center for 12-inch (300 mm) diameter signals. The receptacle shall have a grip to hold the lamp securely. Rotation of the receptacle for positioning the lamp filament shall be possible without using tools.

(h) Wiring for each lamp receptacle shall be provided by color coded No. 18 AWG (1 mm<sup>2</sup>) insulated stranded copper conductors of sufficient length to extend, without splicing, to the terminal block located within each signal face with the reflector and holder in a fully open position.

**902.4.1.1 Aluminum Conventional Signal Heads.** The signal section shall be a self-contained assembly consisting of an optical unit, section housing, housing door, terminal block and necessary gaskets to ensure a weatherproof unit. It shall be capable of separate mounting or inclusion in a signal face containing two or more signal sections. If existing housings are to be combined with new housings, the new housings shall be adaptable to the existing. All new signal sections shall meet the following requirements:

(a) Each housing shall be die cast aluminum having back, sides, top and bottom integrally cast to form a single unit. It shall be clean, smooth and free from imperfections. Each housing shall have a nominal 2-inch (50 mm) opening in the top and bottom with 72 integrally cast serrations around each opening to ensure positive locking of the sections. The connection between signal housings shall be weatherproof and capable of being directed at any angle in the horizontal plane in 5-degree increments. Housings shall be rigidly fastened together by a three bolt assembly or other connectors approved by the engineer.

(b) Housing doors shall be suitably hinged and held securely to the body of the housing by corrosion resistant locking devices. All door parts shall be of corrosion resistant material. Gaskets which will exclude dust and moisture shall be used between the body of the housing and the door, between the lens and the door and between the lens and the reflector.

(c) The optical unit shall consist of a lens, reflector, lamp receptacle, wiring and shall be designed in conjunction with the visor to eliminate the return of outside rays entering the unit from above the horizontal.

(1) Lenses shall meet the requirements of ANSI D 10.1. Lettering shall not appear on lenses except for pedestrian signals. Signal lens nominal diameter shall be as specified. Arrow lenses shall be of the size, color and design specified. Dull or dark gray enamel shall be applied to the convex surface of the lens so that only the arrow indication will be illuminated. The enamel shall totally hide the light from a 200-watt lamp. The enamel shall be baked or fired into the glass, be hard and durable and not peel or flake.

(2) Aluminum reflectors meeting the requirements of ANSI D 10.1 shall be furnished with a non-corrosive holder mounted either in the housing or on the door. The holder shall be so arranged that the reflector can be swung out or completely removed. The mounting shall be sufficiently rigid to ensure proper alignment between the lens and reflector when the door is closed.

**902.4.1.2 Polycarbonate Conventional Signal Heads.** All material used in construction of this type signal head shall be of ultraviolet stabilized color-impregnated polycarbonate resin.

Painting of signal heads will not be permitted. Each traffic signal face shall consist of a number of identical signal section housings rigidly fastened together. The design of the housing shall be such that, with the aid of simple tools and the addition of standard parts, it shall be possible to make any assembly consisting of one or more signal sections and, with the addition of standard bracket assemblies, assemble signal faces into multi-way traffic signal head configurations.

(a) The housing of each section shall be one piece with sides, back, top and bottom integrally molded. It shall have a minimum thickness of 0.09 inch (2.2 mm) and shall be ribbed to produce added strength. Internal bosses or inserts shall be provided in each housing for mounting a terminal block and attachment of backplates. The top and bottom exterior of the housing shall be flat to ensure perfect alignment of assembled sections. The top and bottom of the housing shall have a nominal 2-inch (50 mm) diameter opening with 72 molded serrations around each opening to ensure positive locking of the sections and pipe bracket. The connection between signal housings shall be weatherproof and capable of being directed at any angle in the horizontal plane in 5-degree increments.

(1) Housings shall be rigidly fastened together by a three-bolt assembly or by other connectors approved by the engineer. Positive locked positioning shall be provided when this type signal is used with serrated brackets, post top, mast arm or span wire fittings. Minimum 0.10-inch (2.5 mm) aluminum plates shall be furnished and installed inside and outside the section housing at all points of attachment of pipe bracket if the signal head is top of post or span wire mounted unless section housing ribbed design prohibits such.

(2) The housing door of each signal section shall be one piece and hinged to the housing. When closed, the door shall be secured to the housing with two stainless steel wing screws. Each door shall have provisions for attachment of a standard or tunnel visor.

(3) Gaskets which will exclude dust and moisture shall be used between the body of the housing and the door, between the lens and the door and between the lens and the reflector.

(b) The optical unit shall consist of a lens, reflector, lamp receptacle, wiring and necessary gaskets to ensure a weather-tight unit.

(1) Lenses shall be made of a polycarbonate material with a minimum 1 1/2-inch (38 mm) convex surface and shall have a minimum 1 3/4-inch (44 mm) clearance between the inside surface of the lens and the lamp. Continuous illumination from a standard 150-watt traffic signal lamp shall not cause distortion of the polycarbonate lens when tested for 24 hours at 75 F (23 C) plus or minus 5 F (3 C) with the signal head in normal position. Glass lenses of approved design may be substituted at the option of the contractor. Glass lenses of the same diameter shall be interchangeable with the polycarbonate lenses. Lens design shall conform to applicable ITE and ANSI specifications and standards. For polycarbonate lenses, arrow indications shall be formed only by a metal mask behind the lens. Painted polycarbonate lenses shall not be used. The lens and reflector, in conjunction with a molded gasket and lamp receptacle, shall form a sealed unit.

(2) Reflectors shall be made of high purity aluminum spun to shape and treated by the Alzak process design having an aluminum reflective surface. Reflectors shall have a minimum concavity of 4 5/8 inches (117 mm), measured

from the electrical contact at the bottom of the bulb socket to the rim of the reflector. Reflectors shall conform with applicable ITE specifications and standards.

(3) A lamp receptacle retainer shall be provided which can be installed or removed without the use of tools. Retaining rings designed to encompass and be embedded into the receptacle exterior surface will not be permitted.

#### **902.4.1.3 Visors and Louvers.**

(a) Standard cut-away visors shall be made from sheet aluminum not less than 0.050 inch (1.25 mm) thick or polycarbonate material not less than 0.090 inch (2.25 mm) thick. Visors shall fit tightly against the door and not permit any perceptible filtration of light between them and the housing door. Visors shall be at least 9 1/2 inches (240 mm) long for all signals. Visors shall angle downward not less than 3 nor more than 7 1/2 degrees. All visors shall be held in place by four stainless steel fastening screws or bolts. All visors shall be capable of being removed without opening the signal head door.

(b) Tunnel visors shall be of the same material and thickness and be within the downward tilt range of standard cutaway visors. Nominal length of tunnel visors shall be 8, 12 or 16 inches (200, 300 or 400 mm) as specified. Tunnel visors shall have an open slot at the bottom.

(c) Louvers shall be marked as to degree of cut-off. The degree of cut-off shall be stamped on the louver or printed on a decal on the front of the louver and be visible after installation. Louvers, if specified in the contract, shall be installed in a tunnel visor with the fins or baffles in a vertical position.

(1) Fixed louvers shall be formed of 0.025-inch (0.6 mm) sheet aluminum. The top and bottom bends of each fin shall be securely fastened to the inside of the supporting ring. The angles of cut-off from either side of the center axis of the light beam shall be provided by six types of louvers: Type A - 3 degrees, Type B - 7 degrees, Type C - 10 1/2 degrees, Type D - 14 degrees, Type E - 18 1/2 degrees and Type F - 26 1/2 degrees.

(2) Adjustable louver units shall be composed of an ABS plastic housing and polycarbonate baffles. The unit shall be designed to prevent light leakage between the housing and the visor. The unit shall have an adjustable view range of 7 to 42 degrees. All plastic materials shall be ultraviolet stabilize. All hardware shall be brass or stainless steel.

**902.4.1.4 Hardware.** All hardware shall be 1 1/2-inch (38 mm) galvanized steel or unfinished aluminum, except that aluminum pipe brackets shall have a spun finish. Elbows, tees and crosses shall be straight threaded and furnished with a square head set screw at each connection point to ensure rigid mounting. Fittings which attach to the signal housing shall incorporate serrations or, by the use of an adapter ring, be compatible with the serrations on the signal housing. Fittings shall be secured to the signal housing by a closed threaded nipple and hex nut. Cast nipples shall not be used.

**902.4.1.5 Backplates.** Backplates, as shown on the plans, shall be provided on all signal heads. The backplates shall be black in color and constructed of flat pre-cut 0.250-inch (6 mm) thermoplastic or 0.125-inch (3 mm) preformed thermoplastic having rolled out edges. Stainless steel bolts, nuts and flat washers shall be used to fasten the backplate to the head. Bolt lengths shall be selected to not interfere with maintenance operations. Any connection to the top of any signal section shall be watertight.

**902.4.1.6 Optically Limiting Signal Heads.** The signal section shall be a self-contained assembly consisting of an optical unit, section housing, housing door, terminal block and necessary gaskets to ensure a weatherproof unit. It shall be capable of separate mounting or inclusion in a signal face containing two or more signal sections. If existing housings are to be combined with new housings, the new housings shall be adaptable to the existing. All new signal sections shall meet the following requirements:

(a) Each signal housing shall be die cast aluminum having a chromate preparatory treatment. The signal housing and lens holder shall be predrilled for backplates and visors. All access openings shall be sealed with weather resistant gaskets. Hinge and latch pins shall be corrosion resistant metal. The lens holder and interior of the housing shall be optical black. The housing shall mount to standard 1 1/2-inch (38 mm) fittings as a single section, as a multiple section face or in combination with conventional signals. The signal housing shall be provided with an adjustable connection that permits incremental tilting from zero to 10 degrees above or below the horizontal while maintaining a common vertical axis through the mounting assembly. Housing connection shall permit external adjustment about the mounting axis in 5-degree increments. Attachments such as visors, backplates or adapters shall readily fasten to mounting surfaces without affecting weatherproof characteristics and light integrity of the signal.

(b) The optical system shall consist of an objective lens, optical limiter-diffuser, lamp, lamp fixture and optical masking tape.

(1) The objective lens shall be a high resolution planar incremental lens, hermetically sealed within a flat laminant of weather resistant acrylic or approved equivalent. The lens shall be symmetrical in outline and if rotated to any 90-degree orientation about the optical axis, shall not displace the primary image.

(2) The optical limiter-diffuser shall provide an accessible imaging surface at focus on the optical axis for objects up to 1200 feet (365 m) distant and permit an effective veiling mask to be applied as determined by the desired visibility zone. The optical limiter-diffuser shall be provided with positive positioning and composed of heat resistant glass.

(3) The lamp shall be 150-watt, 120-volt AC, sealed beam with an average rated life of at least 6000 hours. It shall have a three prong base and an integral reflector. The lamp shall be attached to the diffusing element with a collar having a specular inner surface.

(4) The lamp fixture shall consist of a separately accessible housing and integral lamp support, an adjustable ceramic socket and a self-aligning, quick release lamp retainer. Electrical connection between section housing and lamp housing shall be accomplished with an interlock assembly which disconnects the lamp holder when the door is opened.

(5) A signal lamp intensity control shall be supplied in each signal section to provide dimming of the signal lamp as the ambient light intensity drops below approximately 3 footcandles (32 lux).

(6) Each signal section shall be installed and directed and the optical limiter masked, in accordance with manufacturer's instructions to provide indications in accordance with the plans or as directed by the engineer.



**902.4.1.7 Pedestrian Signal Heads.** Pedestrian signal heads shall conform to ITE specifications and standards for pedestrian traffic control signal indications and the following:

(a) Pedestrian signal head housings shall be constructed of a one-piece, 0.250 inch (6 mm) thick, polycarbonate material. The housing shall include an integral mounting bracket designed for side-of-pole mounting on all makes of signal poles with a terminal compartment and minimum 5-position, double-row terminal block.

(b) The door, lens and any openings in the housing shall have gaskets or seals to exclude dust and moisture from the inside of the compartment.

(c) Reflectors shall be parabolic and constructed of high purity aluminum or polycarbonate material with scratch resistant reflective coating. Aluminum reflectors shall be spun to shape and treated by the Alzak process design having an aluminum reflective surface. Lenses shall be constructed of polycarbonate material.

(d) Pedestrian signal head units shall be provided with a manufactured, preformed rectangular visor or screen-type louver.

(e) All plastic materials shall be ultraviolet stabilized.

(f) Indications shall be ITE Class 3 symbol messages. The "DON'T WALK" hand symbol shall be illuminated with a portland orange LED module. The LED module shall conform to applicable portions of [Sec 902.4.1\(b\)](#).

#### **902.4.2 Signs and Luminaires.**

**902.4.2.1 Signs.** Signs for signal installations will be furnished by the Commission. They shall be mounted as shown on the plans. The contractor shall furnish all material required for sign mounting.

**902.4.2.2 Luminaires.** Luminaires shall meet the requirements of [Sec 901.4.3](#). Light distribution shall be Type M-S-III.

#### **902.4.3 Posts and Mast Arms.**

**902.4.3.1 Steel Pedestal Posts.** Steel pedestal posts shall be 4 1/2-inch (114 mm) outside diameter schedule 40 steel pipe. The base shall be cast iron, free from imperfections and provided with a suitable plastic, fiberglass or cast door for wiring access. A grounding lug shall be provided inside the base. The bolt circle and hole diameter shall be as shown on the plans. After fabrication, posts and bases shall be hot-dip galvanized inside and out.

**902.4.3.2 Aluminum Pedestal Posts.** Aluminum pedestal posts shall be schedule 80 straight tubing of 6063-T6 aluminum alloy conforming to the requirements of ASTM B 210, with a 4 1/2-inch (114 mm) outside diameter. The pedestal base casting shall be either permanent mold casting of Alloy 356.0 F, conforming to the requirements of ASTM B 108 or sand castings of Alloy 356.0 F, conforming to the requirements of ASTM B 26. The base shall be free from imperfections and provided with a suitable door for wiring access. The base and post shall be joined by threaded connection. Welded connections will not be accepted. A grounding lug shall be provided inside the base. All hardware shall be non-ferrous metal or stainless steel.

**902.4.3.3 Steel Posts and Mast Arms.** Steel posts and mast arms shall be continuously tapered, hollow shafts fabricated as one continuous shaft or as individual segments, not less

than 10 feet (3 m) in length, joined together using electrically welded, intermediate, transverse, full penetration, circumferential joints. Steel posts and mast arms shall be fabricated from basic oxygen or open hearth steel sheet. The continuous, tapered, hollow shafts or individual segments shall be manufactured from one or two lengths of steel sheet, with one or two continuous, welded, longitudinal seams. The longitudinal seams in the mast arm shall be located outside of the upper half of the cross section of the member. Where transverse, full penetration, circumferential welds are used, the fabricator shall furnish to the engineer written certification that 100% of all such welds have been radiographed by an independent testing agency using a qualified non-destructive testing technician, as described in Section 6.14.7 of ANSI/AWS D1.1-96, and equipment calibrated annually. The testing agency shall be approved by the engineer prior to fabrication. Post base and mast arm attachment plates shall be plate steel attached to the larger end of the shafts by continuous welds on the inside and outside of the shaft. After manufacture, the material shall have a minimum yield strength of 48,000 pounds per square inch (330 MPa). A handhole equipped with a suitable metal cover shall be provided in the post near the base and 12 inches (300 mm) above the mast arm connection if luminaire mounting is specified. A grounding lug or connector shall be provided inside the post near the handhole. A removable metal cap shall be provided on the top of the post and on the small end of each mast arm. All handhole covers and metal caps shall be attached to the post or arm with a galvanized steel chain. The chain shall be welded to the inside of the post or arm and be of sufficient length to allow maintenance access. All anchor bolt nuts shall be completely covered by the post base or by nut covers. Luminaire bracket arms, when specified, shall be included with the post and mast arm, and no direct payment will be made. The contractor has the option to furnish posts with shape, gage and dimensions meeting or exceeding those required by the plans and specifications, provided shop drawings are submitted and approved in accordance with [Sec 902.4.3.3.1](#).

**902.4.3.3.1** Four copies of shop drawings reflecting design and stress details shall be submitted to the engineer and be approved in writing prior to fabrication of the signal posts or installation of supporting bases. Shop drawings shall indicate complete details required for fabrication including material grades, thicknesses, welding and orientation of any longitudinal seams. The projected area of signs and the weights (masses) of signs and signals used in the design of the post and mast arms shall also be shown on the shop drawings. All welding procedures to be used shall be prepared by the manufacturer as a written procedure specification and shall be submitted with the shop drawings for approval. Approval of the weld procedures will be required before approval of the shop drawings. The shop drawings shall indicate the specific approved welding procedure to be used for each joint. Shop drawings and supporting stress calculations shall also be signed and sealed by a registered professional engineer retained by the manufacturer. Fabricators may submit four copies of shop drawings showing design details for all possible post combinations for pre-approval to the engineer. Upon written approval, these pre-approved drawings and weld procedures may be used on any project where the design loading conditions of the shop drawings are not exceeded. If pre-approved drawings are used, the manufacturer and drawing numbers used shall be submitted to the engineer and be approved in writing prior to the installation of the signal posts or supporting bases. Four copies of applicable pre-approved drawings shall be supplied with the posts.

**902.4.3.3.2** Welding and fabrication of the assemblies shall be in accordance with the ANSI/AWS D1.1-96 Structural Welding Code-Steel, and no later edition thereof. All requirements of the welding code for tubular structures shall apply to the fabrication for the post and mast arm shafts and shall include any welds used to attach these members to plates or other hardware. The manufacturer shall employ qualified personnel to perform all visual and nondestructive testing (NDT) required. In addition to the visual inspections and NDT that may otherwise be required by the welding code, the manufacturer shall perform 100 percent

magnetic particle (MT) testing of circumferential fillet welds used to attach the flange plate to the larger end of the mast arm shaft. NDT personnel shall be qualified as set forth in paragraph 6.14.7 of ANSI/AWS D1.1-96. Qualifications of NDT personnel shall be submitted to the engineer for approval.

**902.4.3.3.3** The post and mast arm manufacturer shall be certified under the American Institute of Steel Construction (AISC) certification program. Conventional Steel Building or higher category. Evidence of current AISC certification will be required prior to the approval of shop drawings, and lapsing of the certification will be cause for the manufacturer's removal from the approved list of suppliers.

**902.4.3.3.4** Steel posts, luminaire bracket arms, mast arms, nut covers and plate steel bases shall be hot-dip galvanized inside and out after fabrication, visual inspections and NDT testing. Galvanized material shall be handled in a manner to avoid damage to the surface. Any galvanized material on which the coating has been damaged will be rejected or may, with the approval of the engineer, be repaired in accordance with [Sec 712.14](#).

**902.4.3.3.5 Fabricator's Certification.** Prior to erection of the posts and mast arms, the contractor shall furnish to the engineer a fabricator's certification in triplicate. The certification will specifically state the fabricated posts and mast arms have been quality control inspected by the fabricator and all material and manufacturing processes used were in full compliance with the specification requirements and the approved shop drawings and weld procedures. The certification shall be accompanied by supporting documentation which shall include the results of the visual inspections and NDT required by [Sec 902.4.3.3.2](#) and copies of the pre-approved drawings required by [Sec 902.4.3.3.1](#).

**902.4.3.4 Span Wire Assemblies.** Span wire assemblies shall include 3/8-inch (10 mm) steel messenger wire, all bolts, nuts, washers, clamps, cable straps and other appurtenances shown on the plans or necessary for proper installation. Messenger wire shall be Class A galvanized, high strength grade, seven wire strand conforming to the requirements of ASTM A 475. Clamps shall be fabricated from low alloy steel. Steel posts for span wire assemblies shall have wire inlets and cable guides with 1 1/2-inch (38 mm) raintight insulator bushings and other features specified in the contract and shall meet applicable requirements of [Sec 902.4.3.3](#). Wood poles and steel posts for span wire assemblies shall be as specified in the contract and as shown on the plans. No direct payment will be made for luminaire bracket arms, if specified. No direct payment will be made for conduit, junction boxes, service entrance caps and any attachment hardware or other appurtenances on the wood poles or steel posts as shown on the plans.

**902.4.4 Power Supply Assembly.** The power supply assembly shall conform to [Sec 901.4.5](#).

**902.4.4.1 Luminaire Control.** If luminaires are specified as part of the signal conduit and wiring system on the signal posts or on separate light poles, a lighting control cabinet shall be provided and installed as shown on the plans. The lighting control cabinet shall contain a control panel constructed of the same material as the cabinet. Circuit breakers, photoelectric switch, a contactor if specified and any other specified equipment for luminaire control shall be installed on the panel. Control cabinets shall be of sufficient size to house all equipment as shown on the plans. Cabinets shall be dusttight, watertight, NEMA 4 and constructed of aluminum or stainless steel. All hinges, catches and other hardware shall be stainless steel. Cabinets shall have a No. 2 Corbin cabinet lock. Photoelectric switches and contactors shall conform to [Sec 901.4.4](#). Circuit breakers shall be Type B circuit breakers conforming to [Sec 901.4.4](#).

**902.4.5 Traffic Controller Assemblies.** Traffic controller assemblies are defined as the complete assembly of all required equipment and components for control of traffic signal indications. Each assembly shall consist of a controller cabinet, signal controller, back panel, conflict monitor, all required wiring, switches and connectors and all other equipment as defined in these specifications and as shown on the plans. Double controller assemblies to control two intersections shall consist of a controller cabinet, two signal controllers, two back panels, two conflict monitors all required wiring, switches and connectors and all other equipment as defined in these specifications and as shown on the plans.

(a) Each controller and its associated equipment shall be designed to operate on 120 volts, 60 hertz, single phase, alternating current.

(b) Variations in the voltage of the power supply of plus or minus 10 percent or sustained temperatures inside the cabinet between -20 F (-28 C) and 165 F (74 C) shall not change the total time cycle of pretimed controllers or the length of any interval, portion, period or unit extension of actuated controllers by more than 5 percent or cause electrical or mechanical damage. Heater elements shall not be used to attain compliance with these requirements.

(c) Vibration shall not affect normal operation of any equipment.

(d) All controllers and other specified auxiliary equipment shall be properly protected with fuses on each applicable unit. Fuses shall be installed in 1/4 twist or screw-in type fuse holders. Pop-out fuse holders shall not be used.

**902.4.5.1 Controller Cabinets.** Controller cabinets shall be cast aluminum or 0.125 inch (3 mm) reinforced sheet aluminum alloy and be of clean-cut design and appearance. The cabinet shall provide ample space for housing all equipment and components. Controller cabinets housing solid state controllers shall be furnished with unused cabinet space measuring 18 inches (450 mm) wide by 12 inches (300 mm) high by 12 inches (300 mm) deep unless coordination equipment is specified on the plans. For pretimed and actuated NEMA controllers, cabinet size shall be not less than 54 inches (1370 mm) high by 38 inches (965 mm) wide by 25 inches (635 mm) deep and support a twelve position backpanel. Double controller cabinets for two controllers shall be not less than 57 inches (1450 mm) high by 74 inches (1880 mm) wide by 17 inches (430 mm) deep and shall support two twelve position back panels. All double cabinets shall have two doors that are hinged on the outside corners of the cabinet so that the doors open away from each other. Double cabinets shall have a divider between the two halves of the cabinet with an 8-inch (200 mm) opening between the compartments at the bottom of the divider for wiring between the compartments. The cabinet shall contain a rigid mounting table, sliding ways or hinged support of such construction that the controller and auxiliary equipment may be withdrawn from the cabinet without breaking any electrical connections or interrupting normal controller operation. Hinged supports shall be welded to the controller cabinet. Electrical connectors on the controller and auxiliary equipment to all circuits shall be NEMA 1/4 twist or MS type. Components of controller cabinets shall meet the following requirements.

(a) A hinged door or doors shall provide complete access to the interior of the cabinet. Door holds shall be furnished which shall hold the door in an open position at least 90 degrees from the closed position. The doors shall fit against a raintight gasket. Each door shall be provided with a cabinet lock and shall have a stamped or raised outside designation, "Traffic Control" or other approved identification. An auxiliary door, positioned on each main cabinet door, equipped with a raintight gasket, shall allow access to a switch panel and shall be equipped with a lock whose key will not unlock the main door. Two keys shall be furnished for each type lock used. The door hinges and pins shall be of corrosion resistant metal. Pins

shall be rolled or solid rod, at least 1/8 inch (3 mm) in diameter, except if continuous hinges are furnished, the pins shall be continuous the full length of the hinges and shall be not less than 1/16 inch (1.5 mm) in diameter.

(b) The back panel in all controller cabinets shall be hinged at the bottom to permit the top of the panel to be rotated forward and down to an angle of not less than 45 degrees with all components, including load switches, attached for maintenance purposes. The bottom of the back panel shall be not less than 6 inches (150 mm) above the bottom of the cabinet.

(c) Cabinets housing solid state controllers shall have a thermostatically controlled ventilating fan with exhausting capability, in an enclosure, of at least 150 cubic feet per minute ( $0.07 \text{ m}^3/\text{s}$ ) for cabinets up to 30.5 cubic feet ( $0.9 \text{ m}^3$ ) and at least 250 cubic feet per minute ( $0.12 \text{ m}^3/\text{s}$ ) for cabinets 30.5 cubic feet ( $0.9 \text{ m}^3$ ) and more, installed in the top of the cabinet. These cabinets shall be supplied with a replaceable furnace type fiberglass filter of at least one square foot ( $0.06 \text{ m}^2$ ) area mounted behind louvers in the lower one fourth of the door.

(d) Each controller cabinet shall be furnished with a clearly labeled switch mounted in the access or police panel to place the signals on flash. Operation of this switch shall not affect the electrical power supply to the controller.

(e) Each cabinet shall be provided with a grounded service outlet and a switch controlled lamp receptacle.

(f) Each cabinet shall contain a separate aluminum power panel containing the following equipment.

(1) One Type B circuit breaker conforming to [Sec 901.4.4](#). The breaker shall interrupt power to the controller and signals. The frame size and trip rating is shown on the traffic signal plans or designated in the contract.

(2) One Type B circuit breaker conforming to [Sec 901.4.4](#). The breaker shall be an auxiliary breaker which interrupts power to cabinet lamp and receptacle. The frame size and trip rating shall be 15 amperes.

(3) One mercury contactor controlling power to the signal bus.

(4) One radio frequency line filter.

(5) One line surge protector.

(6) One terminal block for AC power input.

(7) One ground bus terminal block.

(8) One isolated neutral bus terminal block.

(g) If specified, a manual operation push button shall be installed in the police panel. The push button shall be wired for manual operation of the signals. The push button shall be water resistant and designed to protect the user against electrical shock and shall be supplied with a coiled cord with a nominal 6 foot (2 m) stretched length. A clearly labeled switch shall also be installed in the police panel to switch between manual or automatic operation of the controller.

**902.4.5.2 Flasher Unit.** Each controller, through terminal options, shall permit yellow-red or red-red flash operation. Indications shall be flashed at not less than 50 nor more than 60 flashes per minute, with approximately 50 percent dwell time. A two circuit flasher, alternate flash and three flasher field circuits for each of the two flasher circuits will be required. A separate flasher shall provide flashing pedestrian indications when required by the contract. The timing of flashing pedestrian intervals shall be separately adjustable from all other timed intervals. The flasher shall be solid-state with ratings not less than 15 amperes per circuit and shall comply with the latest revision of NEMA Standards Publication TS. The flasher units shall have 150-volt metal oxide varistor (MOV) placed on each output flash terminal. Uniform code flash circuitry is required for each controller. Flashing operation shall be in accordance with the MUTCD.

**902.4.5.3 External Time Switches.** External time switches shall be solid state, key board entry and contain filtering and shielding circuitry to protect the unit's operation against electrical interference. Timing shall be based on the 60 Hz power supply frequency. Each unit shall contain a programmable automatic central daylight time compensation feature. Each unit shall contain a back-up power source to maintain time and memory functions during loss of AC power. Each unit shall provide a weekly program with at least 20 event changes per week.

**902.4.5.4 Wiring.** All wiring shall be insulated, stranded copper wire and shall be neatly bundled and secured with plastic cable ties. For double controller cabinets, all wiring for each intersection shall be terminated in the same compartment of the cabinet as the signal controller for that intersection. Incoming field circuits shall be routed horizontally from the conduit to the back of the cabinet, then vertically to the terminal block. All terminals shall be labeled and not be visibly obstructed. All field leads shall be identified by means of round aluminum identification tags with a minimum thickness of 0.1 mils (2.5  $\mu$ m) attached to the cables with a copper wire to correspond with the plans. The outgoing signal circuits shall be of the same polarity as the line side of the power supply and the common return of the signal circuits shall be of the same polarity as the ground side of the power supply. The power supply shall be provided through three single conductor cables. The ground side of the power supply shall be carried throughout the controller in a continuous circuit and shall be secured to a ground bus bar in an approved manner. All field conductors shall be terminated in the controller cabinet on a 600-volt heavy duty one piece mechanical screw connector offset tang assembly attached to a barrier terminal strip. Each mechanical screw connector shall accommodate up to four No. 12 AWG (4 mm<sup>2</sup>) conductors. The connector shall be mounted horizontally on the inside of the cabinet back approximately 6 inches (150 mm) from the bottom of the cabinet. All wiring to the terminal strips except the incoming field circuits shall be performed by the controller manufacturer. The terminal strips shall mount at least:

- (a) Two terminals for the power supply.
- (b) An unfused terminal for neutral side of power supply line.
- (c) One terminal for each signal lamp circuit and one terminal for the common return from each signal face.
- (d) If detectors are used:
  - (1) Two terminals for each detector.
  - (2) Screw terminal strips mounted vertically on the side of the cabinet approximately 6 inches (150 mm) from the bottom of the cabinet.

(3) All inductive loop detector inputs shall be protected with a 30-volt metal oxide varistor (MOV) with a 30 J rating.

(e) Terminals for interconnect cable when the controller is to be hard-wire interconnected shall be fused and provided with a 150-volt metal oxide varistor (MOV) with an 80 J rating.

(f) Terminals for closed loop system interconnect cable shall be fused and provided with a 30-volt oxide varistor (MOV) with a 30 J rating.

**902.4.5.5 Back Panel Wiring.** All wiring on the back side of the controller back panel shall be neatly bundled and secured with plastic cable ties. Any multiconductor cable between the controller or auxiliary equipment and the back panel shall be contained in an expandable braided sleeving. All wiring shall be discrete insulated wires and shall be soldered directly to lugs on the back of terminal blocks and sockets. Printed circuit boards shall not be used. Regardless of the number of phases specified on the plans, all load switch positions shall be completely wired for use. If no pedestrian phases are specified, twelve position back panels for actuated NEMA controllers shall be configured for operation of eight phases and four overlaps. If pedestrian phases are specified, twelve position back panels shall be configured for operation of eight phases and four pedestrian phases or a combination of overlaps and pedestrian phases if specified on the plans. Twelve position back panels for pretimed controllers shall be configured for operation of 36 circuit outputs from the controller unless otherwise specified on the plans. A flash transfer relay socket shall be provided for each pair of load switch positions. Flash circuit 1 shall be wired to positions 1, 3, 5, 7, 9 and 11. Flash circuit 2 shall be wired to positions 2, 4, 6, 8, 10 and 12. All flash transfer relay sockets shall be fully wired for operation. All controller harness wiring shall be connected to labeled terminals on the front of the panel.

**902.4.5.6 Solid State Controllers.** This section describes the general specifications for both pretimed and actuated solid state controllers. If requested by the engineer, the contractor shall provide a prototype controller for testing and evaluation.

(a) Each controller shall be solid state keyboard entry and the circuit design shall use microprocessor techniques.

(b) Timing shall be accomplished in a digital manner by counting the 60 Hz power supply frequency. Timing circuits, interval and phase switching functions shall be accomplished by solid state circuitry. It shall not be necessary to remove or change wires or use any tools to make timing interval adjustments. The controller shall indicate the right of way conditions of the phase timing interval in effect, detector or actuation on each phase and memory conditions or demand on each phase for vehicles and pedestrians by use of status lights or display panels.

(c) Opening and closing of signal lamp circuits shall be performed by plug-in solid state load switches, rated at not less than 10 amperes and loaded no greater than 6.7 amperes, located external to the controller. All load switch jacks shall be completely wired to field output terminal strips. Actuated and pretimed controllers shall have a minimum of twelve load switch jacks. Each load switch shall provide three independent circuits with "on" indicator lamps and shall comply with the latest revision of NEMA Standards Publication TS.

(d) Each controller assembly shall contain a conflict monitor external to the controller circuitry conforming to NEMA Standards Publication TS. The monitor shall cause immediate transfer to flashing operation when conflicting or absent indications occur or when a voltage fault occurs. When the conflict monitor actuates flashing operation, the controller

shall freeze or stop timing in the condition causing the actuation until manually reset. A single lamp failure in any signal head shall not cause the monitor to actuate.

(e) For double controller cabinets, two sets of switches are provided, one set for each controller installed in each compartment. Each controller cabinet shall be furnished with the following switches:

(1) Power Interrupt Switch - A switch located inside the main cabinet shall interrupt electrical power to the controller during maintenance on the controller. Operation of this switch shall not affect the flash operation. This switch shall not be accessible via the police panel.

(2) Flash Switch - A switch mounted in the police panel shall place the signal on flash. Operation of this switch shall not affect the electrical power supply to the controller. When the signals are returned to normal operation the external start shall be activated causing the controller to revert to the programmed initialization phase(s).

(3) Stop Time Switch - A three position switch mounted inside the main cabinet shall provide the following functions:

a. Stop Time - Causes the controller to stop time.

b. Normal - Allows the controller to cycle all phases, but during conflict monitor flash causes the controller to stop time.

c. Run - Allows the controller to cycle all phases and during any flashing operation allows the controller to continue cycling all phases without displaying them on the signal heads.

(f) During flash condition, controller operation shall permit the cycling of all signal phases without an external load being connected to the field terminals.

(g) Solid state controllers shall have electronic filters to prevent interference caused by the opening and closing of circuits in electro-mechanical auxiliary equipment.

(h) The controller shall be of modular design. Each module shall be constructed for individual removal and replacement in the controller by multiple prong jacks or outlets without modifying wiring. Hand operable positive locking devices shall be used to hold the modules securely in the controller.

(i) The functional operating circuits and their associated components shall be grouped in plug-in printed circuit assemblies. Similar assemblies shall be interchangeable between controllers manufactured by the same company.

(j) The controller shall contain the necessary phase sequence, interval sequence timing, power supply and monitoring equipment required to supervise the operation for the phasing shown on the plans, including any future controller expansion. If future phases are specified, the controller shall be completely configured to accept the future phases.

(k) Controllers which are interconnected shall have a coordinated/free operation switch. This switch will allow the controller to operate in coordination with the system or run free.



(l) High energy transient surge protection shall be provided on all solid state controllers to minimize damage to the controller and auxiliary equipment. This device shall be located on the incoming 120 volts, 60 Hz power service between the controller and signal circuit breaker and the power inputs to the controller and auxiliary equipment. The arrestor shall meet the latest NEMA specifications for surge protection.

(m) All flash operation called from a source external to the controller shall occur through the flash transfer relay.

(n) Any multiconductor cable shall be contained in an expandable braided sleeving.

(o) Switches or relays which completely interrupt power to the signal heads other than the protective circuit breaker shall not be installed in the cabinet.

(p) All controllers shall be capable of downloading all programming data to a printer via a front panel RS-232 connection. The controller shall be capable of printing directly to a printer or via an external PC computer. If an external computer is required, the required PC software shall be provided with the controller.

(q) All controllers shall be provided with internal pre-emption functions and circuitry.

**902.4.5.6.1 Solid State Pretimed Controller.** Each solid state pretimed controller shall be modular by function with keyboard entry. Solid state pretimed controllers shall meet the following requirements:

(a) Timing intervals or periods shall be set by means of keyboard entry unless otherwise specified. Each timing interval shall be adjustable to any value within the following ranges:

Name	Range
Cycle Length	30-255 seconds
Offset	0-254 seconds or 0-99%
Interval	0-12.7 in 0.1 seconds increments or 0-127 in 1 second increments
Pre-Empt - Delay - Interval	0-255 seconds 0-12.7 in 0.1 second increments or 0-127 in 1 second increments

Each interval in the signal sequence shall have a programmed backup timing stored on (EE) PROM which shall operate in case of memory failure.

(b) Each controller shall have the following minimum operational characteristics:

- (1) Four separate signal plans.
- (2) Four cycle lengths.
- (3) Three offsets per cycle.
- (4) Four splits per cycle.
- (5) Forty signal circuits.

- (6) Twenty-four intervals per split.
- (7) Four detector inputs.
- (8) Optional initialization in flash or programmed interval.

All internal terminal points for the above operational characteristics shall be brought out to a terminal strip, either vertical or horizontal and then to the backpanel and various switches described herein.

(c) Each controller shall be furnished with five position, hand operated rotary switches mounted inside the controller cabinet. These switches shall permit the manual selection of the following:

- (1) Signal Plan 1, 2, 3, 4 or System.
- (2) Cycle Length 1, 2, 3, 4 or System.
- (3) Offset 1, 2, 3 or System (Master only).

When in the system position, selection of operational conditions shall be accomplished by command voltage applied to the control terminal strip.

(d) Solid state pretimed controllers shall be designated as Type S-M, S-S or S-N.

(1) Type S-M controller provides an output with a 3-second sync pulse once each cycle, beginning at offset 0.

(2) Type S-S controller shall operate as an interconnected unit which receives all operational commands from a Master Controller, Time Base Coordination Unit or Time Switch.

(3) Type S-N controller shall operate as a non-interconnected unit and be furnished with internal time based functions.

(e) A control terminal strip, vertically or horizontally mounted, shall be located 6 to 8 inches (150 to 200 mm) above the bottom of the cabinet. Control voltages applied to the terminal shall cause the following operational conditions to occur:

Terminal Number	Operation Condition
1	Sync - (Offset 1)
2	Cycle 3
3	Cycle 2
4	Signal Plan 2 - Split 2
5	Offset 2
6	Flash
7	Signal Plan 3 - Split 3
8	Cycle 4
9	Signal Plan - Split 4

All command voltages applied to these terminals shall be 120 volts AC. Interface circuitry between this terminal strip and the controller shall be by solid state or relay logic. In the absence of a command voltage, the controller shall revert to timing plan 1, cycle 1, offset 1 and split 1.

(f) Pre-emption circuitry shall be accomplished without the use of the minimum four separate signal plans and shall be internal to the controller.

**902.4.5.6.2 Solid State Actuated Controller.** Each solid state actuated controller shall meet the latest revision of NEMA Standards Publication TS. Actuated controllers shall meet the following requirements:

(a) Recall by keyboard entry shall be provided for each phase to furnish continuous recall. With the recall function in the "OFF" position the controller shall operate normally with the right of way being transferred only upon pedestrian or vehicle actuation or external force-off control.

(b) Controllers shall be furnished with provisions for external maximum control for each signal phase complete with wiring to permit installation of a coordination unit. All wiring to facilitate coordination shall be terminated on terminal strips and complete information stating the function of each terminal shall be shown on the controller wiring diagram.

(c) All phases shall contain a non-locking memory feature. This feature shall be energized or de-energized by keyboard entry.

(d) All phases shall be activated or inactivated by keyboard entry.

(e) On the cabinet inside door test panel, an external push button switch for each vehicle and pedestrian phase shall be provided. Each switch shall provide call to the phase assigned and ability to extend the phase. This detector input shall be independent of the circuitry between the amplifier and backpanel.

(f) On controller cabinets with internal coordination in a 7- or 12-wire or tone interconnect system, a MoDOT D-plug shall be provided between the D-plug on the controller and the interconnect panel on the cabinet. In the absence of the sync signal, the coordination interface shall be configured to cause the controller to default to free operation. Configuration of the MoDOT D-plug shall be as follows:

Pin	Assignment	Pin	Assignment	Pin	Assignment
D1	Cycle 1	D10	Split 4	D19	Future (Pre-empt 4)
D2	Cycle 2	D11	Offset 1	D20	Flash
D3	Cycle 3	D12	Offset 2	D21	Hardware Interconnect*
D4	Cycle 4	D13	Offset 3	D22	Future
D5	Future (Cycle 5)	D14	Future (Offset 4)	D23	Future
D6	Future (Cycle 6)	D15	Future (Offset 5)	D24	Future
D7	Split 1	D16	Pre-empt 1	D25	Future
D8	Split 2	D17	Pre-empt 2		
D9	Split 3	D18	Pre-empt 3		

\* Omit when activated through the cycle, split or offset inputs.

The MoDOT D-Plug shall be a Cinch TRW Super D Connection as follows:

1 - Part #TB 25 P	Plug	1 - Part #SHD-25GL	Hood with Latch
1 - Part #TB 25SLB-1	Socket	1 - Part #SHD-25GFCS	Hood with Filler Ends

(g) Actuated controllers shall be fully configured for operation of a minimum of eight vehicle phases, four pedestrian phases and four overlaps regardless of the number of phases shown on the plans.

**902.4.5.6.2.1 Timing Function.** Timing intervals or periods shall be set by means of keyboard entry. Each timing interval shall be adjustable to any value within the following minimum ranges for each phase. Zero may be satisfied by a time increment of up to 100 milliseconds.

Interval	Range
Minimal Initial	0 - 99 seconds
Unit Extension or Passage Time	0 - 9.9 seconds
Yellow Clearance	0 - 9.9 seconds
Red Clearance	0 - 9.9 seconds
Maximum I Green	0 - 99 seconds
Maximum II Green	0 - 99 seconds
Walk	0 - 99 seconds
Pedestrian Clearance	0 - 99 seconds
Seconds per Actuation	0 - 9.9 seconds
Maximum Initial	0 - 99 seconds
Time Before Reduction	0 - 99 seconds
Time to Reduce	0 - 99 seconds
Minimum Gap	0 - 9.9 seconds

**902.4.6 Auxiliary Equipment and Interfaces for Controllers.** Interface panels shall be aluminum panels installed in the controller cabinet containing the required terminals and equipment. Interface panels shall be neatly laid out, neatly wired and easily accessible. Each auxiliary unit shall be enclosed in a suitably finished metal case. It shall be mounted in the controller cabinet unless otherwise specified. The function of each auxiliary unit shall be indicated by an identification plate on the case. Auxiliary equipment cases shall be ventilated. Temperature, voltage and frequency shall meet the requirements of [Sec 902.4.5](#).

**902.4.6.1 Pre-emption Interface.** The pre-emption interface shall consist of internal pre-emption functions in the controller, any field wire termination panels, relays, wiring and connectors required for proper operation. The pre-emption interface shall be wired to transfer control of the signals to the pre-emption sequence when actuated and shall provide the color sequence specified. After release of pre-emption, normal controller operation shall be automatically resumed except that actuated controllers shall be on recall for one complete cycle.

**902.4.6.2 Master and Local Coordination Interface.** The coordination interface shall consist of internal coordination functions in the controller. The coordination interface shall also consist of any field wire termination panels, wiring and connectors required for proper operation. The master coordination interface shall supervise the actuated controller operating the signals in the intersection at which it is located. Local coordination interfaces shall be supervised by the master coordination interface and shall in turn supervise the actuated controllers operating the signals at the intersections where they are located. Coordination interfaces shall be connected to one another or to a telephone interconnection unit by a multi-conductor cable. The master coordination interface shall be furnished with internal time-based functions in the controller. The coordination interface shall provide the following:

- (a) Fully actuated operation.

(1) Cycle length of the actuated controller may vary with traffic demand but shall not exceed the cycle length set on the coordination interface.

(2) Vehicle and pedestrian detectors shall remain energized.

(3) During periods of light traffic, the actuated controller shall respond to detector demand on any signal phase.

(4) When there is continuous demand for all signal phases, the coordination interface shall cause termination of each signal phase in accordance with the time intervals set on the coordination interface for each signal phase.

(5) The actuated controller shall not be forced to transfer right of way to a signal phase if there is no demand.

(b) Semi-actuated operation.

(1) Signal phases controlling the street on which signal progression is desired shall be placed on maximum recall.

(2) Vehicle and pedestrian detectors shall remain energized.

(3) Transfer of right of way from the coordinated signal phase(s) shall not occur until there is detector actuation for a non-coordinated signal phase and only after the coordination interface has terminated the coordinated signal phase(s).

(4) The right of way interval awarded the coordinated signal phase(s) shall be governed by the time interval set on the coordination interface.

(5) If detector actuations for a non-coordinated signal phase(s) causes the phase(s) to time to maximum, the phase(s) shall be forced off and the coordinated phase(s) awarded right of way.

(6) If demand for the non-coordinated signal phase(s) is not sufficient to extend the phase(s) to maximum, right of way shall transfer to the coordinated phase(s) and remain there until demand for the non-coordinated phase(s) occurs and the coordination interface times the coordinated phase(s) to maximum.

(7) Detector actuation on a non-coordinated signal phase(s) occurring during the coordinated phase(s) right of way interval shall cause a call to be placed and retained for the non-coordinated signal phase(s).

(c) Fixed cycle length operation.

(1) All signal phases shall be placed on maximum recall.

(2) Vehicle and pedestrian detectors shall remain energized.

(3) The coordination interface shall control the time interval that each signal phase is awarded right of way.

(d) Free operation.

(1) When permitted by internal time-based functions, the coordination interface shall provide free operation of associated actuated controllers. During this operation the actuated controller shall operate without supervision by the coordination interface.

(2) Pretimed controllers, in a signal system supervised by a master coordination interface, shall revert to dial 1, reset 1 or internal time based coordination during free operation at the users option.

**902.4.6.2.1** Each coordination interface shall have the following minimum operational characteristics:

- (a) Three cycles.
- (b) Eight splits.
- (c) Eight force off periods per split.
- (d) Three offsets per cycle.
- (e) Selectable recall by signal plan.

**902.4.6.2.2** Each coordination interface shall have all of the following methods of synchronizing to the master sync pulse:

(a) Dwell. The coordinator shall establish a new offset by stopping the cycle timer in the coordinated phase(s) green, until the new offset value is reached.

(b) Dwell with Interrupt. The coordinator shall establish a new offset by stopping the cycle timer in the coordinated phase(s) green. The maximum time the coordinator can dwell shall be adjustable from 1 to 99 seconds.

(c) Shortway. The coordinator shall establish a new offset by the shortest route possible.

**902.4.6.2.3** Each master coordination interface shall be furnished with necessary relays and internal functions in the controller to provide the following supervisory functions:

(a) Semi-actuated operation.

(b) Fixed cycle length operation.

(c) Free operation.

(d) Cycle Transfer (cycle 1 to cycle 2, cycle 3 or cycle 4 and vice versa; cycle 2 to cycle 3 or cycle 4 and vice versa; cycle 3 to cycle 4 and vice versa).

**902.4.6.2.3.1** Each controller shall be capable of permitting the manual selection of the following:

(a) Cycle Length 1, 2, 3, 4 or System.

(b) Offset 1, 2, 3, 4 or System.

- (c) Semi-actuated operation, fixed cycle length operation or free operation.

**902.4.6.3 Tone Transmitter and Receiver Units.** Tone transmitter and receiver circuitry and frequency determining components shall be solid state, except input and output relays and switches. The system shall employ tone transmitting and receiving techniques. It shall be possible to transmit and receive a minimum of nine control functions utilizing either fixed frequency or frequency shift keyed tone techniques. Equipment shall be modular and provide continuous operation within limits established by the local telephone company. Cycle and reset selection shall be independent. Free operation shall occur in the continued absence of the dial function tone transmission. Synchronization of the traffic signals shall be obtained by the tone signal for reset 1, reset 2 or reset 3. The synchronization command shall occur once every dial cycle. A single pair, multi-point, voice grade telephone line shall be used to interconnect master controller with one or more local controllers by a single transmitter and multiple receivers. All components and modules of the same type shall be interchangeable. It shall be possible to transpose transmitters and receivers without damage to either. Indicator lights shall be provided with each transmitter and receiver to indicate the functions in operation. Application of a 120-volt AC control voltage to the input terminals of the transmitter shall cause a contact closure in the receiver to place 120 volts AC to the corresponding output terminals. Relay contacts shall be rated not less than 275 VA. Double-pole, double-throw, dust-tight relays or switches shall be provided for plug-in connections to sockets on all receiver and transmitter chassis.

**902.4.6.3.1** The transmitter unit shall permit the selection of cycle 1, cycle 2, cycle 3, reset 1, reset 2, reset 3 and three other functions. Transmitter characteristics shall be as follows:

- (a) Output Level; at least 0 dbm, continuously adjustable to -25 dbm or less.
- (b) Tone Stability; plus or minus 0.2% center frequency.
- (c) Output Stability; plus or minus 1.5 db.
- (d) Harmonic Distortion; 42 dbm or less.
- (e) Output Impedance; 600  $\Omega$  nominal, balanced, with rising characteristics outside the passband.

**902.4.6.3.2** The receiver unit shall cause the selection of flash, cycle 2, cycle 3, reset 1, reset 2, reset 3 and three other functions. Receiver characteristics shall be as follows:

- (a) Sensitivity; adjustable within the minimum range of -40 to +5 dbm. (Channel monitoring set at -40 dbm).
- (b) Filter Characteristics; at least 3 db down at 62 Hz and 35 db down at 120 Hz above and below center frequency.
- (c) Input Impedance; 600  $\Omega$  nominal.
- (d) Dynamic Range; not less than 10 db.

**902.4.6.3.3 Operating Frequencies and Functions.** Transmitter and receiver units shall be furnished with the following frequencies:

Group One	870 Hz	Cycle 2
	900 Hz	Flash
	930 Hz	Cycle 3

Group Two	1110 Hz	Reset 2
	1140 Hz	Reset 1
	1170 Hz	Reset 3

Group Three	1350 Hz	Future Use
	1380 Hz	Future Use
	1410 Hz	Future Use

**902.4.6.3.4** Switching logic shall permit selection of only one function at one time in groups one and two. In group three, logic switching shall apply 120 volts to the respective output terminals of the tone receiver when the 120-volt control voltage is applied to the tone transmitter input terminals as follows:

<b>Transmitter Terminals</b>	<b>Receiver Terminals</b>
F1	F1
F2	F1 + F2
F3	F1 + F3
F1 + F2	F1 + F2
F1 + F3	F1 + F3
F2 + F3	F1 + F2
F1 + F2 + F3	F1 + F2

**902.4.6.3.5** Each tone transmitter and receiver shall have a front mounted socket for testing purposes. A level adjustment control shall be accessible at the front of each unit.

**902.4.6.3.6** A NEMA 1/4 twist or MS type connector with 6 feet (2 m) of cable shall be provided for supplying electrical power to the unit and from the control circuits to the signal control equipment. A separate two-wire plug and jack connector with 6 feet (2 m) of cable shall be provided for connection to the telephone line terminals.

**902.4.6.3.7** The contractor shall make necessary connections for installing transmitter and receiver units in the signal controller cabinets and to the telephone company's terminal boxes. After equipment has been approved by the engineer, Form D-25 provided in the contract shall be completed and mailed to the address shown, with a copy to the engineer. The contractor shall contact the telephone company for the terminal box and information on installation regulations of the company.

**902.4.6.4 Remote "ON - OFF" Switch (Pedestrian Interval Sequence).** The following type "On - Off" switches shall be furnished as specified:

(a) Type I. This item shall consist of one manually operated heavy duty switch in a circuit not exceeding 18 volts. Necessary relays shall be located in the controller cabinet for including or excluding the pedestrian phase in the phasing sequence or switching signals between flashing and sequence operation. This shall be accomplished by energizing or de-energizing the pedestrian signal indications and push-button detectors. The switch shall be enclosed in a weatherproof, cast aluminum housing equipped for post mounting. The housing shall have a suitable lock, the key of which shall not unlock the controller cabinet. The housing shall be tapped for conduit.



(b) Type II. This item is operationally identical to Type I except the switch may be 120 volts and shall be located in the access panel of the controller cabinet.

**902.4.6.5 Time Base Coordination Interface.** The time base coordination interface shall consist of internal time base coordination functions in the controller.

(a) Timing base shall be the 60 Hz power line frequency. Timing error due to power failure or low voltage shall not exceed plus or minus 0.005 percent during these conditions. Changes to and from standard time and daylight time shall be programmed to automatically occur at the specified times. Memory and timing shall be maintained for at least 48 hours during an AC power failure. A power failure indicator shall be provided.

(b) The interface shall have a multi-digit security access code or key and lock security access.

(c) The interface shall be zero time based, settable to the second, programmable for 52 weeks, accommodate at least three weekly programs, twelve day programs and not less than twelve exception day programs. Total event changes shall not be less than 160. It shall be possible to interrogate the interface to determine the year, month, day, hour, minute, second, a.m. and p.m., as well as program information programmed in the unit. Indicators shall show the condition of all outputs.

(d) The interface shall permit the controller to operate free or in coordination. When in coordination, all maximum green limits shall be inhibited. The interface shall be capable of continuously generating not less than four cycle lengths from 40 to 255 seconds.

(e) The interface shall be capable of continuously generating eight individual force-off commands in each cycle length even though it may not be necessary to use all of the force-off commands. It shall also place a continuous call to the detector inputs of the coordinated phases. Position of the force-off and continuous call functions shall be settable at any percentage point or seconds in any selected cycle length.

(f) The first program of the day shall be implemented at the beginning of the minute selected. When changing from one cycle length to another while in the coordination mode, the change to the new cycle length shall not occur until the present cycle length has terminated. If the controller is operated in the free mode between cycle lengths, the next cycle length programmed shall begin at the beginning of the minute selected.

(g) The interface shall be furnished with the capability of generating a daily reference point at which time all cycles are resynchronized. This daily reference point shall be either 12:00 midnight or a selectable time of which 12:00 midnight could be selected. The resynchronization reference time is an arbitrary point in time which marks the beginning of all cycles on a daily basis.

(h) When designated, the interface shall be capable of generating an absolute reference point at which time all cycles are resynchronized. This absolute reference point shall be a selectable time by date and hour and minute which marks the beginning of all cycles.

(i) While under coordination, the designated coordinated phase(s) shall be capable of releasing from a hold status and operating in the actuated mode. The controller unit shall operate in actuated mode from a designated hold release point to the corresponding force-off point(s) of the coordinated phase(s).

(j) Three instruction manuals covering operational information shall be furnished with each interface.

#### **902.4.7 Detectors.**

**902.4.7.1 Probe-Type Detectors.** Probe-type detectors shall be as specified on the plans and shall conform to the following:

(a) The sensing probes shall be cylindrical having maximum dimensions of 7/8 inch (23 mm) diameter by four inches (100 mm) long. The sensing probes shall be suitable for installation in a one inch (25 mm) diameter bored hole. The interconnecting four conductor cable and lead-in cable shall be suitable for installation in a 1/4 inch (6 mm) wide pavement sawed slot.

(b) The jacket on the interconnecting cable and the casing on the sensing probe shall be an abrasion resistant polyurethane elastomer. The device shall be impervious to moisture and chemically resistant to all normal motor vehicle petroleum products. Lead-in cables shall be shielded, chemical resistant and completely waterproof.

(c) The combined probe sets, manufacturer specified lead-in cable and detector probe shall detect all vehicles up to a lead-in cable length of 750 feet (228 m) with up to six probes per set.

(d) The conductor cable from the probes to the detector panel in the controller assembly shall be as specified by the detector manufacturer, shall be continuous and unspliced and shall be a minimum of 50 feet (15 m) in length. Probes shall be assembled in a set to form a vehicle detector as shown on the plans. No more than six probes shall be assembled as a set. The cables between probes shall be long enough to provide the spacing shown on the plans plus 5 feet (1.5 m). If no spacing is shown, 15 feet (4.5 m) of cable shall be provided between probes. Each set of probes shall have one lead-in cable.

(e) Probes installed under bridge decks shall be protected by completely encapsulating them in a conduit system. The probes shall be oriented so that the detection zone is above the bridge deck and shall be installed in gasketed junction boxes anchored to the bottom of the deck. The junction boxes shall have a minimum size of 6 x 6 x 4 inches (150 x 150 x 100 mm) and the probes shall be rigidly anchored in the box. The probes shall be no more than 18 inches (450 mm) below the top of the bridge deck. Conduit shall be sized so that the probe and cable can be pulled through the conduit. Any conduit bends shall be such that probe and cable can be pulled through the bend. External conduit on the structure shall conform to [Sec 902.5.3](#).

**902.4.7.1.1 Magnetometers.** Each sensing probe shall consist of a sensitive flux gate magnetometer. The magnetometer shall operate properly when excited by a triangular current of plus or minus 75 mA peak at five kHz. For a single probe in a magnetic field of 400 millioersted, the return signal shall be at least 50 mV RMS at ten kHz. The return signal shall reverse phase when the field passes through zero millioersted.

(a) Probe set operation shall be unaffected by temperature change, water and ice. The probes shall be operational in power line AC magnetic fields ranging to 100 millioersted peak to peak. The probe set shall be operational at -35 F (-37 C) to +165 F (+74 C).

(b) Shelf mount or card rack mount magnetometer detectors shall be provided as shown on the plans. Detectors shall be operational with magnetometer detector probes.

Detectors shall be capable of detecting vehicles stopped within the field of the probes or passing over the probes at speeds up to 80 mph (130 km/h). Detectors shall conform to the requirements of induction loop detectors except for the following:

- (1) Sensitivity shall be set electronically.
- (2) All detectors shall have delay and extend timing functions up to a minimum of five seconds.
- (3) Shelf mount units shall have two detection channels.

**902.4.7.1.2 Induction Detector Probes.** The encapsulated induction detector probe shall detect the passage or presence of all vehicles with a standard induction loop detector amplifier.

(a) The induction detector probe shall operate in a temperature range from -35 F (-37 C) to +165 F (+74 C) with 0 to 100 percent humidity.

(b) The operating field intensity range shall be 0.2 to 1.0 oersted with a nominal inductance of 20  $\mu$ H plus 20  $\mu$ H per 100 feet (30 m) of cable. The nominal DC resistance shall be 0.5  $\Omega$  plus 3.2  $\Omega$  per 100 feet (30 m) of probe cable.

**902.4.7.2 Push-Button.** Pedestrian push-button detectors shall be direct push contact type. Each detector shall be a removable contact assembly mounted in a cast aluminum case. The housing shall be shaped to fit the curvature of the post to which it is attached and shall provide a rigid installation. Contacts shall be normally open, entirely insulated from the case and operating button and have connecting terminals. The case shall have one outlet tapped for 1/2-inch (13 mm) pipe. The operating button shall be recessed and made of brass or corrosion resistant metal alloy or non-metallic material. The operating voltage shall not exceed 24 volts. The entire assembly shall be weatherproof, secure against electrical shock to the user and of such construction as to withstand continuous hard usage.

**902.4.7.3 Induction Loop Detectors.** Induction loop vehicle detectors shall detect a vehicle stopped within the field of the loop or passing over it at speeds up to 80 mph (130 km/h). Induction loop detectors shall be card rack mounted. The contractor may provide shelf mounted detectors for a controller with four or fewer induction vehicle loops. For double controller cabinets, detectors shall be installed in the same compartment as their associated controller. If card rack detectors are specified, two card rack assemblies shall be installed, one for each controller. The following requirements shall apply to shelf mounted and card rack mounted detectors:

(a) Shelf mounted detectors shall incorporate a single detection channel. Card rack mounted detectors shall incorporate two detection channels.

(b) Each detector channel shall have at least a two frequency selection capability, at least two levels of operational sensitivity and be capable of tuning to a minimum inductance range of 70 to 1000  $\mu$ H.

(c) All controls and indications shall be mounted on the front panel of the sensing unit, with the exception of extension and delay timing controls on card rack mounted detectors.

(d) A manual control shall be provided for each channel to select pulse or full presence operation.

(e) Each detector channel, after installation and initial adjustment, shall automatically tune itself to various loop configurations ranging in size from 6 x 6 feet (1.8 x 1.8 m) minimum to 6 x 100 feet (1.8 x 30 m) maximum, up to a maximum lead-in length of 750 feet (230 m).

(f) Each detector channel shall time out and retune itself automatically if it senses a continuous vehicle occupation of the loop field for a nominal time of 10 to 30 minutes.

(g) In event of power loss to the detector or channel, a continuous call shall be made to the controller.

(h) All circuitry shall be of solid state, digital design and incorporate temperature compensating components, with the exception of the output relay.

(i) If specified, each channel shall have extension and delay timing features, as follows:

(1) Delay timing range from 0 to 30 seconds in 1.0 second increments.

(2) Extension timing range from 0 to 7.5 seconds in a maximum of 0.5 second increments.

(j) The sensing unit shall have a light which shall illuminate when a vehicle is within the loop field. Other visual indications of relay closure may be used if approved by the engineer.

(k) Each detector and channel shall comply with NEMA Standard Publication TS.

**902.4.7.3.1 Shelf Mounted Detectors.** Each shelf mounted inductive loop detector unit shall be self-contained. The main chassis shall include the power supply, line fuse and MS type connector.

(a) The MS connector shall be a chassis jack, type MS3 102A-18-1P and cable plug, type MS3160A-18-1S, with a type MS3057-10 cable clamp and boot.

(b) Wire size for the cable shall be 18 AWG (1 mm<sup>2</sup>) minimum and continuous between the connections and the detector panel. Minimum cable length shall be 6 feet (1.8 m).

(c) The pin connection shall be as follows:

Pin	Function
A	120 VAC (Common)
B	Relay Output (Common)
C	120 VAC (Line)
D	Loop Input
E	Loop Input
F	Relay Output (Normally Open)
G	Relay Output (Normally Closed)
H	Chassis Ground
I	Spare
J	Time Control

**902.4.7.3.2 Card Rack Mounted Detectors.** The supporting and connecting rack for this type detector shall contain space for a minimum of two power supplies and shall have a minimum of eight card positions for two channel detector units. Upper and lower slide guides shall be provided for the power supply and each detector card. Where card rack detectors are specified, the rack and power supplies shall be included with the detectors and no direct payment will be made.

(a) The card mounting rack shall be attached to the controller cabinet by a hinge or pivot assembly which allows the rack to rotate horizontally so as to expose the rack wiring and facilitate maintenance operations. The rack shall be positioned to rotate out freely 90 degrees without conflicting with other wiring, equipment or the controller cabinet. Sufficient wire lengths shall be provided for rotation. The rack shall not block the backpanel or other termination panels.

(b) The power supply shall be capable of supplying a minimum of 200 mA to each detection channel position. The power supply shall be capable of operating a full rack of time delay detectors regardless of the amount and type of detectors required. Each power supply channel shall power no more than one detector card. Each channel shall be individually fused.

(c) Each card rack detector shall have a regulator for the power input. The regulator shall have the appropriate power and voltage rating for operation of the detector.

(d) Card racks shall mate with a 44-terminal, double row, 0.156-inch (4 mm) contact spacing, Cinch Jones card edge connection 50-44A-30M or equivalent. Input/output connector pin terminations shall be in accordance with NEMA Specification TS. All useable functions shall be fully wired for use.

(e) All circuitry shall be of solid state, temperature compensating components.

(f) Unless shown differently on the plans, each detector in the card rack shall be associated with the appropriate phase as follows:

Channel	Card Position							
	1	2	3	4	5	6	7	8
1	ø 1	ø 1 or 6	ø 6	ø 6	ø 3	ø 3 or 8	ø 8	ø 8
2	ø 5	ø 5 or 2	ø 2	ø 2	ø 7	ø 7 or 4	ø 4	ø 4

(g) Each detector channel shall be clearly labeled with phase and direction.

**902.4.7.4 Calling Detector Relay.** A calling detector relay shall operate with any detector and allow the detector to place only one actuation when the red indication is being displayed to its associated phase. The relay shall be self-contained.

**902.4.7.5 Microwave Vehicle Detectors.** The unit shall detect all licensed vehicles moving within the field of detection at speeds from 2 to 80 mph (3 to 130 km/h). The unit shall have a minimum detection range from 3 to 200 feet (1 to 60 m) for all licensed vehicles. The pattern spread of the detection field shall be no more than 16 degrees. The unit shall be self-tuning and capable of continuous operation over a temperature range of -35 F (-37 C) to +165 F (+74 C). The unit shall be microprocessor based using Doppler microwave at an operating frequency of 10.525 GHz. The unit shall have Federal Communications Commission (FCC) certification and be tested to the applicable FCC specifications. The unit shall be capable of side-fire mount or overhead mount. The enclosure shall be constructed of aluminum or stainless steel and shall be water resistant. The unit shall be capable of detecting directional traffic and the direction shall be user selectable. All user operated controls and adjustments

shall be clearly marked and easily accessible. The unit shall have a relay detection output to the controller with a minimum 5 A rating and be designed to place a constant call to the controller in the event of any failure. The unit shall have an easily accessible indicator showing activation of detection relay. Required wiring shall be as specified by the manufacturer. Mounting hardware for the type of mounting shown on the plans and power supply equipment shall be as specified by the manufacturer and shall be provided with the unit.

**902.4.7.6 Ultrasonic Presence Detectors.** The unit shall detect the continuous presence of any object within the field of detection. The unit shall have a minimum detection range from 3 to 24 feet (1 to 7 m) from the front face of the unit and the detection range shall be adjustable. The detection pattern shall be conical with a nominal beam width of 20 degrees. The unit shall be capable of continuous operation over a temperature range of -35 F (-37 C) to +165 F (+74 C). The unit shall be self-tuning and operate in the ultrasonic frequency range. The unit shall be capable of side-fire mount or overhead mount. The unit shall contain a variable detection time delay up to a minimum of ten seconds. All user operated controls and adjustments shall be clearly marked and easily accessible. The enclosure shall be constructed of aluminum or stainless steel and shall be water resistant. The detector shall have a relay detection output to the controller with a minimum 5 A rating and be designed to place a constant call to the controller in the event of any failure. The unit shall have an easily accessible indicator showing activation of detection relay. Required wiring shall be as specified by the manufacturer. Mounting hardware for the type of mounting shown on the plans and power supply equipment shall be as specified by the manufacturer and shall be provided with the unit.

## **902.5 Construction Requirements.**

**902.5.1 Pull and Junction Boxes.** Pull and junction boxes shall be installed in accordance with the applicable requirements of [Sec 901](#).

**902.5.2 Concrete Bases.** Excavation for bases shall be made in a neat and workmanlike manner. Forms shall be sufficiently rigid to prevent warping or deflection. Forms shall be level and shall be held rigidly in place while concrete is being placed. Concrete shall be Class B or concrete of a commercial mixture meeting the requirements of [Sec 501.12](#). Conduit, ground rods and anchor bolts shall be held rigidly in place before and during concrete placement. Tops of all bases shall be finished level and edged to a radius of 1/2 inch (13 mm). Exposed surfaces of bases shall be finished in a workmanlike manner as soon as practicable after removing forms. Concrete shall be placed, finished and cured in accordance with applicable provisions of [Sec 703](#).

**902.5.2.1 Post Bases.** Concrete bases for posts shall conform to dimensions shown on the plans. Metal forms, not less than 26 inches (660 mm) high, shall be used for all Type A bases. The top 12 inches (300 mm) of Type B flush bases shall be formed. Anchor bolts for steel posts and mast arms shall be as shown on the fabricators approved shop drawings. Conduits shall extend above all post bases a nominal 4 inches (100 mm).

**902.5.2.2 Controller Bases.** Concrete bases for controllers shall be a minimum of 3 inches (75 mm) greater on each side than overall base dimensions of the controller cabinet with minimum dimensions being those shown on the plans. A 4-inch (100 mm) thick concrete apron extending 2 feet (600 mm) in front of the base on the door-side of the controller shall be poured. The apron shall be 2 feet (600 mm) wider than the base, extending 12 inches (300 mm) on each side or as shown on the plans. Aprons shall be considered part of the controller base. The anchor bolt size for controller cabinets shall be as specified by the cabinet manufacturer. A minimum of four anchor bolts shall be used for single controller

cabinets and a minimum of six anchor bolts shall be used for double controller cabinets. A ground rod shall be placed in each controller base, extending through the base into the ground with a minimum of 5 feet (1.5 m) of earth contact. Bases for double controller cabinets shall have two ground rods, one positioned in each compartment. Conduits shall extend above all controller bases no more than 1 inch (25 mm). Bases for double controller cabinets shall have two conduits to the first pull box, one positioned in each compartment. All conduit openings in the controller cabinet or controller cabinet base shall be sealed with an approved sealing compound after wiring is completed. This compound shall be readily workable soft plastic.

**902.5.3 Conduit System.** The contractor has the option to furnish and install rigid steel, intermediate metal, polyvinyl chloride (PVC) schedule 40 or heavy duty polyethylene (PE) conduit. Conduit shall be placed a minimum of 18 inches (450 mm) below finished grade and shall slope to a pull box at a minimum rate of 0.5 percent unless otherwise shown on the plans. A change in direction of conduit shall be accomplished by bending the conduit uniformly to a radius which will fit the location or by the use of standard bends or elbows. Minimum radius of the bend shall be six times the internal diameter of the conduit. Nipples shall be used to eliminate cutting and threading where short lengths of conduit are required. If it is necessary to cut and thread steel conduit, no exposed threads will be permitted. All conduit and fittings shall be free from burrs and irregularities. All conduit shall be cleaned and swabbed before cables are installed. All fittings shall be tightly connected to the conduit. Open ends of conduit placed for future use shall be capped or plugged. If approved by the engineer, conduit may be installed either by trenching or pushing; however, payment will be made by the method specified in the contract for that conduit.

**902.5.3.1 Metal Conduit.** All metal conduit ends shall be provided with a bushing to protect the cable from abrasion. All metal conduits shall be electrically bonded by conduit clamps and bare No. 6 AWG (16 mm<sup>2</sup>) stranded copper wire. All metal conduits in the controller base shall be electrically bonded to the power company ground.

**902.5.3.2 Polyvinyl Chloride (PVC) Conduit.** A bare No. 6 AWG (16 mm<sup>2</sup>) stranded copper ground wire shall be installed in each conduit and attached to the ground lug in signal posts or lighting poles, except as otherwise specified in this section. All bare ground wires shall be electrically bonded. All bare ground wires in the controller base shall be electrically bonded to the power company ground. PVC conduit containing only fiber optic cable shall contain a bare or green jacketed No. 14 AWG (2.5 mm<sup>2</sup>) stranded copper tracer wire instead of a bare No. 6 AWG (16 mm<sup>2</sup>) copper ground wire. The tracer wire shall not be pulled into the controller cabinet or bases. An additional 6 feet (2 m) of tracer wire shall be coiled in each pull box through which the fiber optic cable passes. Tracer wire in pull boxes shall be capped, not electrically bonded to any ground wires and tagged "TRACER" in accordance with [Sec 902.5.7.5](#). Payment for ground wire and tracer wire shall be included in the price bid for the conduit.

**902.5.3.3 Conduit in Trench.** Trenches shall be excavated to the width and depth necessary for conduit installation. Material which might cause mechanical damage to the conduit shall not be used for backfilling below an elevation 6 inches (150 mm) above the conduit. The bottom of the trench shall be free of such material before the conduit is placed. No conduit shall be placed without approval of the trench by the engineer. All trenches shall be backfilled as soon as practicable after installation of conduit. Backfill material shall be deposited in the trench in layers not exceeding 6 inches (150 mm) deep. Each layer shall be compacted to the approximate density of the adjacent material before the next layer is placed. Red burial tape imprinted with "CAUTION - BURIED CABLE BELOW" shall be installed in all trenches at approximately 1/3 to 1/2 of the depth of the trench. Where excavation is made across parkways or driveways, sod, topsoil and crushed stone or gravel shall be replaced as nearly as practicable to its former condition. Concrete or bituminous surfaces and stabilized bases shall

be restored to their former condition. The entire area involved shall be left in a neat, presentable condition.

**902.5.3.4 Pushed Conduit.** If pushed conduit is specified, the conduit shall be installed without disturbing the existing surface. Pushed conduit may be placed by jacking, pushing, boring or other approved means.

**902.5.3.5 Conduit in Median.** If conduit in median is specified, it shall be placed on the existing pavement prior to construction of the raised median. If conduit is to be placed in concrete traffic barrier, the conduit shall be held rigidly in place before placement of concrete.

**902.5.3.6 External Conduit on Structure.** For existing structures or if provisions are not made in the plans for providing a conduit raceway in new structures as described in [Sec 707](#), the conduit shall be external conduit on structure. Conduit on structure shall include conduit on bridges, retaining walls or other structures and shall be installed as shown on the plans or as directed by the engineer. The final location of all conduit and junction boxes shall be approved by the engineer before installation is begun. Conduit shall not be attached to prestressed concrete girders or prestressed-precast concrete deck panels. The conduit shall be secured to the concrete with clamps at no more than 5 foot (1.5 m) intervals. Concrete anchors shall meet federal specification FF-S-325, Group II, Type 4, Class I and shall be galvanized in accordance with ASTM A 153, B 695-91 Class 50 or constructed of stainless steel. Minimum embedment in concrete shall be 1 3/4 inches (44 mm). The supplier shall furnish a manufacturer's certification that the concrete anchors meet the required material and galvanizing specifications. If it is necessary to anchor the conduit to steel bridge members, the attachment method shall not involve drilling, grinding or welding. Attachment method to steel members shall be approved by the engineer. Junction boxes shall be installed as shown on the plans or as directed by the engineer. Junction boxes shall be surface mounted and installed such that covers are easily accessible. If the conduit crosses a bridge expansion joint, a conduit expansion fitting shall be used. The expansion fitting shall provide a minimum movement in either direction as shown on plans or as specified by the engineer. No direct payment will be made for junction boxes, expansion fittings and any hardware or material required for conduit installation.

**902.5.4 Signal Faces.** Signal faces shall be covered or turned away from approaching traffic until placed in operation. When ready for operation, they shall be securely fastened in position facing approaching traffic. Horizontally mounted lamps shall be installed by the contractor with the open segment of the filament up. Signal faces shall be aimed laterally at the approximate center of the lane or lanes they control. They shall be aimed at a point back of the stop line a distance corresponding to the following requirements:

<b>Approach Speed mph (km/h)</b>	<b>Distance ft (m)</b>
30 (50)	160 (50)
40 (70)	240 (75)
50 (80)	330 (100)
60 (100)	430 (130)
70 (120)	560 (170)

**902.5.5 Detector Loop.** A slot for installation of induction loop cable shall be sawed in the pavement as shown on the plans. Each loop shall have a separate lead-in slot to the conduit. A separate conduit shall be installed between the sawed loop slot and the first pull box for each loop. The conduit opening at the end of the lead-in slot shall be at the bottom of the sawed slot. The slot shall be brushed or blown clean. The cable shall be pushed into the slot without damaging the insulation. After the loop cable is spliced to the lead-in cable, and



before the slot is sealed, the resistance of the loop and lead-in cable to ground shall be checked. The resistance test shall be performed by the contractor in the presence of the engineer and documented. After a satisfactory test, showing a resistance of not less than 10 MΩ, the slot shall be sealed. The conduit opening at the end of the lead-in slot and any drilled conduit holes in the pavement shall be sealed with a pliable duct sealant prior to application of loop sealant. All sawed slots shall then be sealed with a detector loop sealant approved by the engineer. Detector loop sealant shall be installed in accordance with manufacturer's recommendations. All detector cable between the loop and detector amplifier shall be twisted at least three turns per foot (10 turns per meter).

**902.5.5.1 Microwave and Ultrasonic Detectors.** Microwave and ultrasonic detectors shall be mounted at the locations shown on the plans in accordance with manufacturer's recommendations. All wiring shall be continuous and unspliced from the detector unit to the controller. The contractor shall make any necessary adjustments for proper operation of the detector.

**902.5.6 Post Erection.** Post bases shall be securely anchored to concrete bases. Pedestal posts shall be erected vertically without use of leveling nuts. Metal posts for span wire and cantilever mast arms shall be adjusted by leveling nuts. All posts for span wire and cantilever mast arms shall be raked as directed by the engineer. All signal posts shall be grounded by a bare No. 6 AWG (16 mm<sup>2</sup>) stranded copper wire from the ground lug inside the post to a clamp fastened on metal conduit at the top of the concrete base, to a ground rod if specified or through nonmetallic conduit to the ground bus in the controller.

#### **902.5.7 Wiring.**

**902.5.7.1** All cable runs shall be continuous without splice from the connections in the terminal block of the signal head or disconnect hanger to the terminal strip in the controller cabinet, from the signal terminal block to another signal terminal block or as shown on the plans. When a terminal compartment is provided, all cable runs shall be continuous from the terminal compartment to the terminal strip in the controller cabinet. When parallel connections are required from a signal head on a mast arm to a side of post mounted signal head, cable shall be routed from the controller to the terminal compartment of the signal on the mast arm and then parallel circuited back to the side mounted signal. All other conductor cable combinations to signal heads shall be as shown on the plans or as directed by the engineer. Where double controller cabinets are specified, wires shall be sorted between the controller and first pull box so that field wires enter the associated controller compartment.

**902.5.7.2** Power cable runs shall be continuous without splice from the power disconnect switch located on the power supply to controller cabinet terminals. This power cable shall be encased in conduit of the size shown on the plans. Energized power cables shall run to circuit breakers. The neutral cable shall be terminated on the ground bus bar in the controller cabinet.

**902.5.7.3** Where luminaires are required, pole and bracket cable shall be installed between the luminaire and the power source at the base of the post. Each luminaire shall be connected to its power source by a separate No. 12 AWG (4 mm<sup>2</sup>) two-conductor cable. A premolded fused connector assembly shall be installed on each conductor between the source cable and the pole and bracket cable. The assembly and cable shall be insulated with a protective rubber boot designed for the premolded connector.

**902.5.7.4** Induction loop dimensions shall be as shown on the plans. Exact location of loops shall be determined by the engineer. Each induction loop shall be connected to its detector by a separate lead-in cable. Single-conductor No. 14 AWG (2.5 mm<sup>2</sup>) cable shown on the plans is an approximation of cable quantity required to construct the induction loop. If the number

of turns shown on the plans is not in accordance with the manufacturer's recommendation for the sensing units furnished, the plans will be revised, the induction loop cable field measured and quantities adjusted accordingly. Induction loop detector cable shall be installed in accordance with manufacturer's recommendations. Induction loop detector lead-in cable is shown on the plans as two-conductor No. 14 AWG (2.5 mm<sup>2</sup>) cable. Should the manufacturer recommend a different type cable, the two-conductor cable shall be revised to manufacturer's specification, but shall be completely covered by the contract unit price for loop detector lead-in cable. Cable for loop detectors shall be continuous from the terminal strip in the controller cabinet to a splice with the detector leads in the pull box adjacent to the detector. The conductor splice shall be soldered without open flame. The soldered splice shall then be capped and inserted into a direct buried splice kit.

**902.5.7.5** Where practicable, color codes shall be followed so that the red insulated conductor connects to the red indication terminal, yellow to yellow and green to green. Circuits shall be properly labeled in the controller cabinet and all pull boxes by means of round aluminum identification tags with a minimum thickness of 0.1 mils (2.5 µm) attached to the cables with a copper wire. Information stamped on the tags shall identify equipment served by the conductor cable in accordance with designations used on the plans.

**902.5.7.6** Cables shall be pulled through conduit by a cable grip providing a firm hold on exterior coverings. Cable shall be pulled with a minimum of dragging on the ground or pavement. Frame mounted pulleys or other suitable devices, shall be used for pulling cables out of conduits into pull boxes. Lubricants may be used to facilitate pulling cable. Slack in each cable shall be provided by a 6-foot (1.8 m) loop in each pull box. Where cable enters a junction box, 3 feet (900 mm) of cable shall be coiled in the junction box. All signal posts and controllers shall be grounded by bare No. 6 AWG (16 mm<sup>2</sup>) stranded copper wire.

**902.5.8 Test Equipment.** During installation of equipment and material, the contractor shall furnish the engineer suitable equipment to test all or part of the completed facility to establish compliance with requirements of the contract. Minimum test equipment shall be a voltmeter, ohmmeter and ammeter. For testing induction loop detectors, the contractor shall also provide a suitable 500-volt DC, zero to 100-MΩ range, hand operated, resistance measuring device.

**902.5.9 Test Period.** After the project is open to normal traffic, the contractor shall notify the engineer in writing the date the signal or signal system, will be ready for testing. Upon concurrence of the engineer, the contractor shall place the signal or signal system in operation for a 15 consecutive day test period. If the signal is to operate independently of other signals or signal systems, it shall be tested as a single installation. If the signal is part of a system, the test period shall not be started until all signals in the system are ready to be tested. A system shall be tested as a unit. Any failure or malfunction of equipment during the test period shall be corrected at the contractor's expense and the signal or system tested for an additional 15 consecutive day period. This procedure shall be repeated until the signal equipment has operated to the engineer's satisfaction for 15 consecutive days. The contractor shall, in the presence of the engineer, demonstrate the proper action of the controller's monitor as part of the testing system, if applicable.

**902.5.9.1** When the test period is initiated and until it is completed, following the turn on of temporary traffic signals or after work is begun on an existing signal installation, the contractor shall provide at least one service technician to remain in the area and be available for day, night and weekend trouble calls. The contractor shall furnish the name, address and telephone number where each designated technician can be reached at all times. In the event of a malfunction, the contractor shall provide adequate traffic control for the intersection until the signals are restored to normal operation. Adequate traffic control shall be as shown on the plans or as directed by the engineer. If the signal or signal system malfunctions and a

designated technician cannot be reached or cannot arrive at the intersection in a reasonable time in the judgment of the engineer, then the engineer may exercise the option to direct MoDOT personnel or a third party to correct the malfunction. If this option is invoked, the entire cost of the work performed by MoDOT personnel or the third party will be deducted from the monies due the contractor. These costs will be computed as described in [Sec 108.9](#). Whether or not the engineer elects to correct the signal malfunction, nothing in this specification shall be construed or interpreted to relieve the contractor of any liability for personal injury or property damage that results either directly or indirectly with a signal malfunction during the test period. The contractor and surety shall indemnify and save harmless the State, the Commission, its agents, employees and assigns for any legal liability incurred for such a signal malfunction.

**902.5.10 Painting and Finishing.** All aluminum signal head parts, including the housing, housing door, visors, louvers and backplates, except the mounting brackets and other hardware shall be primed and painted flat black in their entirety. All polycarbonate signal head parts, including the housing, housing door, visors and backplates shall be constructed from ultraviolet stabilized black-impregnated poly-carbon resin. The mounting brackets and hardware, except the aluminum pipe brackets, shall be galvanized steel or unfinished aluminum. Aluminum pipe brackets shall have a spun finish. Painting of the mounting brackets and hardware will not be permitted. All metal parts reused for modification of a signal installation shall be painted in accordance with the requirements for new material. If the painted surface of any equipment is damaged, such surface shall be touched up or repainted in a manner satisfactory to the engineer.

**902.6 Maintenance Information.** Before acceptance of the work, the contractor shall furnish the engineer three copies of the manufacturer's instructions for maintenance and operation of all signal equipment including, but not limited to, controllers, conflict monitors, load switches, detectors and auxiliary equipment. At a minimum, the manufacturer's instructions shall include organized written instructions, wiring diagrams, diagrams showing component layouts and parts lists with part numbers. The contractor shall also furnish three copies of wiring diagrams of the installation or system.

**902.7 Final Clean Up.** Final cleaning up of right of way shall meet requirements of [Sec 104.9](#).

**902.8 Method of Measurement.**

**902.8.1** Measurement of conduit will be made to the nearest linear foot (0.5 m) as shown on the plans. Contract quantities will be used in final payment except as provided in [Sec 902.8.10](#).

**902.8.2** Measurement of conductor will be made to the nearest 10 linear feet (5 m) as shown on the plans. Contract quantities will be used in final payment except as provided in [Sec 902.8.10](#).

**902.8.3** Measurement of concrete for bases, including all specified material, will be made to the nearest 1/10 cubic yard (0.1 m<sup>3</sup>) as shown on the plans. Contract quantities will be used in final payment except as provided in [Sec 902.8.10](#).

**902.8.4** Measurement of traffic controller assemblies, including all specified equipment, will be made per each.

**902.8.5** Measurement of power supply assemblies, including all specified equipment, will be made per each.

**902.8.6** Measurement of detector probes will be made per each. Measurement of shelf mounted detectors, including any wiring harnesses and connectors, will be made per each. Measurement of two channel card rack mounted detectors will be made per each detector card. No direct payment will be made for the card rack assembly and card rack power supplies.

**902.8.7** Measurement of posts, including all specified items, will be made per each.

**902.8.8** Measurement of pull and junction boxes, including all specified material, will be made per each.

**902.8.9** Measurement of signal heads and luminaires, including all required material and hardware, will be made per each.

**902.8.10** For those items on which final payment is based on contract quantities, final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**902.8.11** Measurement of temporary traffic signal installations will be made per lump sum.

**902.9 Basis of Payment.** Accepted traffic signals will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for any incidental items necessary to complete the work unless specifically provided as a pay item in the contract.

## SECTION 903

### HIGHWAY SIGNING

**903.1 Description.** This work shall consist of furnishing and installing highway signs as shown on the plans.

**903.1.1 Signs.** All signs shall conform to the MUTCD. All letters, numerals, arrows, symbols, borders and other features of the sign message shall be as shown on the plans or as approved by the engineer. Any signs not detailed on the plans shall conform to *Standard Highway Signs* by the U.S. Department of Transportation - Federal Highway Administration.

**903.2 Material.** All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Galvanized Coating of Structural Steel, Tubular Steel Sign Supports, Sign Trusses and Appurtenances	712
High-Strength Bolts, Nuts and Washers	712
Low-Carbon Steel Bolts, Nuts and Washers	712
Structural Carbon Steel	712
Structural Low Alloy Steel	712
Low-Carbon Steel Anchor Bolts	901
Reinforcing Steel for Concrete	1036
Highway Sign Material	1042
Delineator, Mile and Marker Posts	1044
Paints for Structural Steel	1045
Electrical Conduit	1060
Electrical Conductors	1061
Pull and Junction Boxes	1062
Expansive Mortars	1066

#### 903.2.1 Sign Posts and Tubular Steel Sign Supports.

Item	Specification
Steel Pipe Posts	ASTM A53, Grade B, or ASTM A 500, Grade B
Galvanizing of Steel Pipe Posts	ASTM A 53
Structural Steel Welding Electrodes	AWS A5.1 or AWS A5.5

### 903.2.2 Overhead Sign Trusses.

Item	Specification
Aluminum Extruded Tube	ASTM B 221, 6061-T6
Aluminum Permanent Mold Castings	ASTM B 108, A 356.0-T61
Aluminum Sand Castings	ASTM B 26, 356.0-T6
Aluminum Plate	ASTM B 209, 6061-T6
Aluminum Structural Shapes	ASTM B 308, 6061-T6
Aluminum Pipe Handrail	ASTM B 241, 6061-T6 or 6063-T6
Aluminum Pipe Fittings for Schedule 10 Pipe	ASTM B 26, 356.0-T6 or ASTM B 108, A 356.0-T61
Aluminum Grating	
Bearing Bars	ASTM B 211, 6061-T6 or ASTM B 221, 6061-T6 or 6063-T6
Cross Bars	ASTM B 211, 6061-T6 or ASTM B 221, 6061-T6 or 6063-T5 or T6
Aluminum Washers	ASTM B 209, 2024-T4 or Alclad 2024T4
Aluminum Beveled Washers	ASTM B 221, 2024-T4
Filler Wire for Welding Aluminum	AWS A 5.10 ER5356, ER5556
Stainless Steel U-Bolts	ASTM A 276 Chromium-Nickel Grade with Min Yield 30,000 psi (200 MPa)
Stainless Steel Bolts, Nuts, Screws and Washers	ASTM A 320 or SAE J405D, Austenitic Steel, Min Yield 30,000 psi (200 MPa)
Structural Steel Welding Electrodes	AWS A 5.1 or AWS A 5.5

**903.2.3** Bolts, nuts and washers specified to be galvanized shall be galvanized in accordance with the requirements of AASHTO M 232 (ASTM A 153), Class C, or mechanically galvanized in accordance with the requirements of AASHTO M 298 (ASTM B 695), Class 55. Galvanizing thickness shall not exceed 6 mils (150 µm). For high strength bolts, the contractor shall furnish to the engineer a copy of the manufacturer's inspection test report for each production lot or shipping lot furnished, and shall certify that the bolts furnished conform to the requirements specified.

**903.2.4** Concrete shall be of the class specified in the contract. Material, proportioning, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#) for the specific class specified. Concrete shall be placed, finished and cured in accordance with the applicable provisions of [Sec 703](#). The entire exposed concrete surface, including sides and top, shall be surface sealed in accordance with the applicable requirements of [Sec 703.3.18](#).

**903.2.5** Equipment and material shall be of new stock unless the contract provides for relocation of existing units or use of units furnished by others. New equipment and material shall conform to the National Electrical Code and the regulations of the National Board of Fire Underwriters, as applicable, and meet the approval of the engineer. A list of pre-approved equipment and material is available through the Division Engineer, Traffic.

**903.2.6** Three copies of the list of electrical equipment and material to be installed will be furnished to the successful bidder, along with the contract for execution. The contractor shall complete the list by writing in the name of the equipment manufacturer and catalog number of each item listed. Two copies of the completed list shall be submitted to the engineer and be approved in writing before the items are installed. Approval of the items on the list does not relieve the contractor of responsibility for satisfactory performance of the installation.

### **903.3 Construction Requirements.**

#### **903.3.1 Footings for Trusses and Posts.**

**903.3.1.1 Bolt-Down Installations.** Class B concrete shall be used to construct all footings and end supports for overhead sign trusses, tubular steel sign supports and posts with bolt-down bases. Footings shall be formed unless in the judgment of the engineer soil conditions permit excavation to be made to the neat lines of the footings and the footings cast against the undisturbed vertical soil face. In all cases the top 12 inches (300 mm) of footings below finished ground line shall be formed. Footings shall be placed on firm, stable, undisturbed soil and to the minimum depth shown on the plans. Backfill shall be thoroughly compacted by mechanical tampers, and care taken to prevent damage to finished concrete. Backfill shall be brought up level with the finished ground line. Anchor bolts shall be firmly held in proper position, supported at the top by a template, during the placing of concrete.

**903.3.1.2 Embedded Installations.** Class B or B-1 concrete, or concrete of a commercial mixture meeting the requirements of [Sec 501](#) shall be used for the footings for embedded type sign posts. The contractor may use a quick setting polyurethane foam for footings in lieu of concrete. The foam shall have a minimum compressive strength of 80 psi (550 kPa), in the direction of rise, when tested in accordance with ASTM D 1621 and shall have a minimum density of 4 pounds per cubic foot (65 kg/m<sup>3</sup>) when tested in accordance with ASTM D 1622. The foam shall not be placed in water. Polyurethane foam shall be mixed in accordance with manufacturer's instructions. Posts shall be supported in proper position until the concrete or foam has set. Excavation and backfill shall meet the requirements of [Sec 903.3.1.1](#), except that no forming will be required unless soil conditions make it necessary. Polyurethane foam will not be permitted if forming is necessary. Top of footings shall be acceptably finished flush with the slope of the ground.

**903.3.1.3 Existing Underground Cable.** Upon request, any information available to the Commission as to the location of cables will be furnished to the contractor without guarantee of accuracy. The contractor shall locate the cable by hand excavation or other approved means when working in the known vicinity of such cable before completing the excavation with power tools. After locating the cable, it shall, if necessary for the construction of footings, be moved by the contractor at the contractor's expense as directed by the engineer. It shall be the contractor's responsibility to report all damages to underground cables to the resident engineer who will notify the owners or their maintaining agencies and determine whether the repairs or replacements are to be made by the owners or their agents, or by the contractor. Regardless of who makes the repair or replacement, it shall be entirely at the contractor's expense. If it is determined that the contractor is to make repairs to damaged cable, the repairs shall be made as directed by the owner, or the work shall be performed in accordance with the following requirements. If the cable sheath is cut or nicked, but the wire undamaged, a protective plastic case shall be installed around the cable. Ends of the case shall be sealed with plastic tape. The case shall then be poured full of insulating compound mixed according to the manufacturer's recommendations. If the conductor is completely severed, it shall be spliced with a pressed sleeve connector or equivalent, and a plastic protective case installed as specified above. If two or more conductors are severed, the contractor shall

identify by continuity tests or other satisfactory means the proper ends to splice. Splicing shall be performed by qualified personnel.

### **903.3.2 Posts for Signs, Delineators and Markers.**

**903.3.2.1** Post lengths shown on the plans for ground mounted signs are for bidding purposes only. When progress of the work permits, the engineer will authorize the location of each sign, with the station and offset distance from the edge of pavement. The contractor shall be responsible for determination of post lengths to provide the vertical clearance shown on the plans. Field cutting of posts shall be performed by sawing. Flame cutting of posts and appurtenances in accordance with [Sec 712.3.3.7](#) will be permitted.

**903.3.2.2** Structural steel sign posts for ground mounting of signs shall be fabricated and erected as shown on the plans, and shall be of material meeting the requirements of AASHTO M 183, AASHTO M 223 Grade 50 or AASHTO M 222, minimum yield 50,000 pounds per square inch (345 MPa). Preheating of the material to be welded is required in accordance with good welding practice and welds shall be of full section and sound throughout. Dimensional defects and structural discontinuities will be cause for rejection. Posts built up by welding two lengths together will be permitted, provided the welds are ground smooth and flush with the base metal. Steel bases shall be arranged for anchoring to concrete footings with galvanized swedged steel bolts of the number and sizes shown on the plans. Posts and appurtenances, such as zee bars and flats, shall be hot-dip galvanized after fabrication. Posts with breakaway assemblies shall be cut at the hinge prior to galvanizing. Hinge plates shall not be attached to the posts at the time of galvanizing. All welds shall be mechanically cleaned before galvanizing. Shop drawings will not be required for structural steel posts.

**903.3.2.3** Steel pipe posts with breakaway assemblies for ground mounting of signs shall be fabricated of black pipe. Steel pipe posts without breakaway assemblies for ground mounting of signs shall be fabricated of galvanized pipe or black pipe hot-dip galvanized after fabrication. Test specimens for galvanized pipe shall be taken at least 6 inches (150 mm) from one end of the pipe instead of at the ends as specified in ASTM A 53 Grade B. Posts with breakaway assemblies shall be fabricated as shown on the plans and shall be hot-dip galvanized after fabrication. Welds shall be of full section and sound throughout. Dimensional defects and structural discontinuities will be cause for rejection. All welds shall be mechanically cleaned before galvanizing. Exposed steel areas and damaged spelter coating shall be repaired in accordance with [Sec 712.14](#), except that edges of drilled holes shall be coated with commercially available zinc-rich paint. Shop drawings will not be required for pipe posts. Friction caps for pipe posts shall be of the dimensions shown on the plans and may be galvanized steel or aluminum alloy.

**903.3.2.4** Mile, delineator and object marker posts shall be driven vertical. Any post bent or otherwise damaged to the extent it is considered unfit for use shall be removed and replaced with an acceptable post by and at the contractor's expense.

**903.3.2.5** The contractor shall furnish fabricators' certifications in triplicate certifying that the material supplied conforms to all of the requirements specified.

**903.3.2.6** Galvanized material shall be handled in a manner to avoid damage to the surfaces. Any galvanized material on which the spelter coating has been bruised or broken will be rejected or may, with approval of the engineer, be repaired in accordance with [Sec 712.14](#).

### **903.3.3 Tubular Steel Sign Supports.**



**903.3.3.1** Tubular sign supports for overhead mounting of signs include span, cantilever and butterfly types, complete with poles, beams, mast arms, sign bracket assemblies, sign lights and other specified appurtenances. All steel material shall be hot-dip galvanized after fabrication. All welds shall be mechanically cleaned before galvanizing. Shop drawings will not be required for these supports.

**903.3.3.2** Tapered steel poles and beams shall be a continuous taper tube, fabricated from one length of open hearth sheet steel with one continuous welded longitudinal seam. After fabrication, the material shall have a minimum yield strength of 48,000 pounds per square inch (330 MPa). Straight steel arms shall be standard or extra heavy pipe, of the dimensions and grades shown on the plans. Handholes and wire outlets for sign lighting shall be provided as shown on the plans. Bolts, nuts, washers, clamps and sign bracket assemblies shall be hot-dip galvanized or of stainless steel. Clamps shall be fabricated of low alloy steel.

**903.3.3.3** The contractor shall furnish to the engineer manufacturer's certification in triplicate certifying that the tubular steel sign supports conform to all of the requirements specified.

**903.3.3.4** Galvanized material shall be handled in a manner to avoid damage to the surfaces. Any galvanized material on which the spelter coating has been bruised or broken will be rejected or may, with approval of the engineer, be repaired in accordance with [Sec 712.14](#).

#### **903.3.4 Overhead Sign Trusses.**

**903.3.4.1** Overhead sign trusses shall be either steel or aluminum and shall include all structural steel, structural aluminum, aluminum castings, pipe railing, gratings, lighting fixtures, supports, electrical system components and appurtenances above the top surface of the concrete.

**903.3.4.2** The general requirements of [Sec 712.3.2](#) will govern, and in addition shop drawings for aluminum members shall be furnished. All drawings shall be furnished to the engineer for approval.

**903.3.4.3** The contractor shall furnish a copy of certified mill test reports on all material furnished, giving the actual chemical analysis and the actual results of physical tests. In lieu of mill test reports for secondary members, the contractor may furnish a certification from the fabricator certifying that the material supplied conforms to all of the requirements of the specifications. All test reports and certifications shall be furnished to the engineer before any requests for shop inspection are made.

**903.3.4.4** Structural steel fabrication and erection shall meet the applicable requirements of [Sec 712](#), except as hereinafter specified.

**903.3.4.5** Before starting fabrication of structural aluminum, all welders shall be qualified by passing, in the presence of the engineer, the requirements of procedure and performance tests of Section 9 of the Boiler and Pressure Vessel Code of the American Society of Mechanical Engineers. Welder qualifications shall be renewed annually. Renewal will be based on a letter from the fabricator certifying that the welder has been engaged in the processes for which the welder qualified without an interruption of more than three months or by requalification. Requalification may be required anytime there is some specific reason to question the welder's ability. Qualification test specimens shall be made at the expense of the contractor, but the specimens will be tested by and at the expense of the Commission. These test specimens shall be made using a base metal of aluminum alloy 6061-T6, and using ER5356 or ER5556 filler metal and inert gas shielded arc.

**903.3.4.6** Aluminum welding shall be carefully checked by the fabricator by visual inspection of all welds, by proof testing of welds and by sufficient destructive testing of weld samples fabricated during the production welding, to verify the reliability of production. Poor welding workmanship as noted by visual inspection will be sufficient cause for rejection.

**903.3.4.7** Contact surfaces of aluminum flange castings shall be finished to give not less than 50 percent contact after assembly, as indicated by the Standard Machinist's Blue Test.

**903.3.4.8** Fabrication of aluminum alloy material shall, in general, conform to the manufacturer's recommendations and the following specific requirements. Flame cutting will not be permitted. All holes in castings shall be cored and reamed for final fit. Welding shall be done by the inert gas shielded arc method and no flux shall be used. Precautions shall be taken to avoid scoring or marring of aluminum surfaces, and any such scoring or marring, which in the judgment of the engineer gives an objectionable appearance, will be cause for rejection. Cast parts shall have all casting irregularities removed. Tubing shall be seamless, and exterior and interior surfaces shall be clean, smooth and free from slivers, laminations, grooves, cracks or other defects.

**903.3.4.9** Shop inspection will, in general, conform to the requirements of [Sec 712.3.1](#).

**903.3.4.10** All steel surfaces except stainless steel and galvanized surfaces, after being inspected and accepted, shall be cleaned and painted with the specified primer in accordance with [Sec 712.12](#). Sandblasting of the inside surface of pipe columns will not be required. All the structural steel may be hot-dip galvanized in lieu of painting. Portions of the steel may be galvanized with the approval of the engineer.

**903.3.4.11** Simulated wind-shop test loading for aluminum trusses will be required as shown on the plans. The load in kips (newtons) and location of the point of application shall be shown on the shop drawings.

**903.3.4.12** Handling and storage of material shall conform to the requirements of [Sec 712.3.6](#). If galvanized high strength bolts and washers are specified, they shall meet the requirements of [Sec 903.2.2](#). If stainless steel bolts are used, they shall be tightened snugly. Connections in which steel and aluminum are in contact shall be protected as shown on the plans.

**903.3.4.13 Field Painting.** All exposed steel surfaces, except galvanized or stainless, shall receive an intermediate coat and a gray finish coat in accordance with [Sec 712.12](#). All items requiring field painting that are to be located over the trafficway shall be fully painted before erection. Care shall be taken to prevent paint splatters on the aluminum portion of the truss.

**903.3.4.14** Galvanized and aluminum material shall be handled in a manner to avoid damage to the surfaces. Any galvanized material on which the spelter coating has been bruised or broken will be rejected or may, with approval of the engineer, be repaired in accordance with [Sec 712.14](#).

### **903.3.5 Sign Erection.**

**903.3.5.1 Storage of Signs.** Signs delivered for use on a project shall be stored off the ground and under cover in a manner meeting the approval of the engineer. Any sign damaged, discolored or defaced during transportation, storage or erection may be rejected.

**903.3.5.2 Fabricator's Certification.** The contractor shall furnish the engineer, prior to sign erection, the fabricator's certification stating, "I hereby certify that only material and manufacturing processes in full compliance with the Missouri Department of Transportation

job specification requirements were used in the fabrication of signs for Job \_\_\_\_\_, Route \_\_\_\_\_, County \_\_\_\_\_."

**903.3.5.3 Erection of Signs.** Sign posts shall be set vertically and true to line so the sign or signs will be level, at the proper angle with the roadway, and with minimum clearances as shown on the plans. Posts with bolt-down base plates shall be plumbed by use of two nuts and washers on each anchor bolt. The space between the base plate and the concrete footing shall be filled with expansive mortar after the sign has been properly mounted. Exposed edges of the mortar shall be finished to present a neat appearance. The mounted sign shall present a smooth flat surface varying not more than 3/8 inch (9 mm) from a 4-foot (1.2 m) straightedge placed in any position on the face of the sign after erection.

**903.3.5.4** Signs on traffic signal posts and lighting poles shall be mounted with strap or clamp type sign supports as shown on the plans or as approved by the engineer.

**903.3.6 Sign Lighting.** Sign lighting includes all work, material, equipment and electrical system components required for lighting signs on overhead structures in accordance with the plans. All electrical equipment and associated construction requirements shall conform to the applicable parts of [Sec 901](#) and the following.

**903.3.6.1 Sign Lighting Fixture.** Sign lighting fixtures shall be designed for use with lamps burning in a horizontal position and for the type of circuit specified. The luminaire shall have an aluminum housing with two 2-inch (50 mm) slipfitters or one 4-bolt slipfitter, and an internal ballast kit designed for that fixture. The housing shall have a natural aluminum finish or gray baked enamel finish. Reflectors shall have an alzak aluminum finish. The refractor shall consist of prismatic heat resistant glass in a cast aluminum holder. Plastic refractors shall not be used. The refractor shall be shielded on the end facing traffic. The holder shall be secured to the luminaire by means of a hinge and an automatic latch. A silicone rubber or other approved gasket shall be used to form a seal between the refractor and housing. The door and refractor assembly shall be completely sealed so that water cannot enter the housing. All metal parts, such as springs on the latches and hinges, U-bolts and screws, shall be made from non-ferrous metal or stainless steel. Wiring inside the luminaire housing shall be protected by suitable heat resistant insulating material. The reflector-refractor optical assembly and the ballast shall form a single unit. The optical unit shall be sealed at the socket entry. Transformer and capacitor compartments of the ballast shall be separated by either a heat barrier or an air gap for lower capacitor operating temperatures. A pipe stop and bracket for 4-bolt mounting shall be included in the assembly to properly locate the luminaire on the aluminum tracking to provide proper placement and illumination as shown on the plans.

**903.3.6.1.1** Lamps shall be mercury vapor or metal halide. Lamp size and type shall be as specified in the contract. The mercury vapor lamp shall have a rated lamp life of not less than 24,000 hours based on a minimum of 10 hours burning time per day. The metal halide lamp shall have a rated lamp life of not less than 10,000 hours based on a minimum of 10 hours burning time per day. The ballast shall be designed for the type of lamp used. The ballast shall be pre-wired to the lamp socket and to a terminal board so that only the connection of the supply leads to the ballast primary terminals is necessary. Ballasts shall be of the constant wattage type for mercury vapor lamps and shall be peak lead auto transformer type for metal halide lamps. Ballasts shall operate satisfactorily over a voltage range of plus or minus 13 percent of its nominal primary voltage rating. The change in lamp wattage over this range shall not exceed 3 percent for mercury vapor and 8 percent for metal halide. The ballast shall start and operate the lamp satisfactorily over a temperature range of -20 F (-29 C) to 105 F (40 C). Ballast efficiency shall not be less than 86 percent. The ballast shall have a power factor of not less than 90 percent. It shall be able to withstand, for at least one minute, twice

the rated primary voltage plus 1000 volts at 60 hertz from primary to core, from secondary to core and from primary to secondary.

**903.3.6.1.2** The luminaire unit shall provide an illumination level no less than 20 footcandles (215 lux) on any part of the sign when mounted as shown on the plans. The illumination uniformity ratio (maximum/minimum) shall be 6:1 or better. The illumination level shall be based on the type of lamp used at 70 percent of the output of a new luminaire. The contractor shall supply photometric data and other documentation to demonstrate that these requirements are met. Documentation shall be submitted to the engineer and be approved in writing prior to installation of sign lighting.

**903.3.7 Wiring and Conduit on Overhead Sign Structures.** Pole and bracket cable shall be installed between the sign luminaires and the power source at the base of the pole. A premolded fused connector assembly shall be installed on each conductor between the source cable and the pole and bracket cable. The connector assembly and splice shall be insulated with a protective rubber boot designed for the premolded connector. Splices shall only be made in junction boxes or luminaire housings as shown on the plans or as approved by the engineer. Splices in junction boxes shall be accomplished with a splice block with a moulded plastic insulating cover. The splice block shall be designed for the wire size used. The splice block shall have one port per wire and the wires shall be secured with set screws. The set screw holes shall be protected with removable plugs. Any required taping shall be accomplished with a rubber, pressure-sensitive, all weather 30-mil (0.75 mm) splice tape. The tape shall be applied half-lap to a thickness equal to 1 1/2 times the thickness of the factory applied insulation and sheath, and taper off over the sheath neatly to a point approximately 3 inches (75 mm) from the conductor splice. Other wire and cable on overhead sign structures shall be as shown on the plans. All external wiring shall be enclosed in rigid aluminum conduit of the size shown on the plans. If flexible conduit is specified, it shall be liquidtight flexible conduit and fittings conforming to Article 351 of the National Electrical Code. Junction boxes shall be stainless steel boxes conforming to [Sec 1062](#). All attachment hardware for conduit and junction boxes shall be stainless steel. No direct payment will be made for conduit and junction boxes on sign structures and any required hardware.

**903.4 Final Clean Up.** Final cleaning up of right of way shall be in accordance with [Sec 104.11](#).

**903.5 Method of Measurement.** For those items on which final payment is based on contract quantities, final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

**903.5.1** Measurement of concrete for footings, including all concrete, excavation, backfilling, reinforcing steel, anchor bolts and nuts, electrical conduit, grout and other incidental items as shown on the plans, will be made to the nearest 0.1 cubic yard (0.1 m<sup>3</sup>). Contract quantities will be used in final payment.

**903.5.2** Measurement of the weight (mass) of structural steel and pipe posts will be computed to the nearest pound (kilogram) for each post and to the nearest 10 pounds (5 kg) for the total, as shown on the plans. These weights (masses) will be computed using the theoretical weight (mass) of the various sections. Contract quantities will be used in final payment.

**903.5.3** Measurement of conductor cable and wire will be made to the nearest 10 linear feet (5 m), as shown on the plans. If two-conductor pole and bracket cable is used in lieu of two single conductor cables, measurement will be made as for two single conductor cables. Contract quantities will be used in final payment.

**903.5.4** Measurement of sign areas will be made to the nearest 1/10 square foot ( $0.01 \text{ m}^2$ ) for each sign and to the nearest square foot ( $0.1 \text{ m}^2$ ) for the total. The area of each sign will be that of the smallest rectangular, triangular or trapezoidal shape that will encompass the sign panel. Contract quantities will be used in final payment.

**903.6 Basis of Payment.**

**903.6.1** Payment for breakaway assemblies including base connection, hinge plate and all other fabrication, complete in place, will be made at the contract unit price each regardless of the post size or shape.

**903.6.2** Accepted highway signing will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for any incidental items necessary to complete the work unless specifically provided as a pay item in the contract.



# **DIVISION 1000**

## ***MATERIALS DETAILS***





## SECTION 1001

### GENERAL REQUIREMENTS FOR MATERIAL

**1001.1** All requirements of [Sec 106](#) shall apply to material hereinafter specified.

**1001.2** All packaged material shall be plainly marked showing the quantity and nature of contents and shall be delivered intact.

**1001.3** A description of the visual characteristics of deleterious rock types most likely to be encountered at any specific aggregate source may be obtained by the supplier upon written request to the engineer.

**1001.4** At local plants installed for production of any sand or gravel required for highway work, the oversize shall not be returned to the deposit or to the stream.

**1001.5** Chat is defined as aggregate tailings from mills in which metallic minerals have been recovered.

**1001.6** Crushed stone is defined as the product obtained by the artificial reduction in the size of rock which has been mined or excavated from ledge formation. Chat as defined in [Sec 1001.5](#) is not included.

**1001.7** Gravel is defined as the coarse granular material, generally considered as material retained on the No. 4 or No. 10 (4.75 mm or 2.00 mm) sieve but may include finer sizes, resulting from the natural disintegration and abrasion of rock or from processing of weakly bound conglomerate. Gravel may include such material which has been further reduced in size by artificial means.

**1001.8** Porphyry is defined as a fine grained, dense, igneous rock generally occurring in the Missouri counties of Iron, Madison, St. Francois and their adjacent counties.

**1001.9** Wet bottom boiler slag is defined as a hard, angular by-product of the combustion of coal in wet bottom boilers.

**1001.10** Sieves specified for gradation requirements shall have openings as prescribed in AASHTO M 92.

#### **1001.11 Storage and Handling of Aggregates.**

**1001.11.1** When coarse aggregate for concrete, bituminous mixtures or Type 4 base is stockpiled, the aggregate shall be handled, placed in horizontal layers, ramped and matted or stockpiled by conveyor belts, as specified below. Coarse aggregate for [Sec 301](#), [401](#) and [402](#) bituminous mixtures is exempt if the aggregate has 90 percent or more passing the 1/2-inch (12.5 mm) sieve. Equipment used in stockpiling and in reclaiming from stockpile, both at the source and the batching plant setup, shall be so operated as to minimize segregation, degradation and contamination.

**1001.11.1.1 Horizontal Stockpiling.** Equipment which moves the material by pushing will be permitted on the stockpile only as necessary for ramp and runway construction and for leveling of the top of a completed lift. When stockpiling, the aggregates shall be deposited in place in successive increments over the length and width of the stockpile. Material in the

layer being placed shall not be allowed to flow down over the edges of the adjacent under layer. The thickness of each layer shall be not more than the thickness of a single deposit from a hauling unit. If trucks or other types of hauling equipment are used, all ramps and runways on the stockpile shall be covered by mats, boards or other approved material. For unloading purposes, hauling equipment will be permitted off the runway a distance of approximately two hauling unit lengths. Clam shells or drag lines when permitted by the engineer for use in stockpiling aggregates specified to be placed in horizontal layers and ramped, shall have areas of travel upon the stockpile covered by mats, boards or other approved material.

**1001.11.1.2 Conveyor Belt Stockpiling.** All conveyor belts, whether mobile or stationary shall have a device fitted to the discharge end of the conveyor to stop the forward movement of the aggregate and mix and discharge the material vertically downward. Only those devices meeting the approval of the engineer will be permitted.

(a) When a mobile conveyor belt is used to stockpile the aggregate with specified stockpile requirements and no further handling is done for stockpiling purposes, the maximum height from the head pulley centerline to the ground surface shall not exceed 15 feet (5 m) when stockpiling is started. After the initial conical pile is built, the vertical free fall of the aggregate shall not exceed 5 feet (1.5 m). The conveyor belt shall be automated to travel laterally or vertically only the distance needed to comply with the free fall requirements. Manual operation of the conveyor will only be allowed for the time necessary to make repairs.

(b) When a stationary conveyor belt is used, the maximum height from the head pulley centerline to the ground surface shall not exceed 30 feet (10 m). Aggregates initially deposited in a conical pile by a stationary conveyor shall be moved at least one more time for stockpiling purposes. The aggregates shall ultimately be stockpiled in horizontal layers and shall comply with [Sec 1001.11.2](#).

**1001.11.2** Regardless of the method of storage and handling, all aggregates which are segregated, degraded or contaminated to the extent that they do not meet specifications, will be considered unacceptable. However, they may be reconditioned by any method which produces satisfactory material. Disposal of unacceptable material shall be the responsibility of the contractor.

**1001.12 Approval of Aggregate Sources.** All sources of aggregate shall be evaluated and approved by the engineer for preliminary approval and final approval as herein prescribed, prior to acceptance of aggregate from that source. Sources shall be resampled a minimum of every five years. Resampling will be required at closer intervals if, in the judgment of the engineer, any significant change has occurred to the source.

**1001.12.1** Sources of crushed stone shall be evaluated for preliminary approval on a ledge by ledge basis. Each exposed ledge will be identified and its boundaries described by the engineer. A sample for preliminary approval is required from each ledge.

**1001.12.2** Sources of gravel and manufactured lightweight aggregates shall be evaluated for preliminary approval, except if a plant-produced product meeting all other specification requirements is available, that product may be evaluated for final source approval without first obtaining preliminary approval. In that case, all preliminary approval and all final approval tests will also be performed, and those limits applied to the final source approval evaluation.

**1001.12.3** Sources of aggregate such as chat, slag and other by-products from previously produced material or any other undefined sources will be evaluated on an individual basis.

**1001.12.4** Samples of aggregate for source final approval will be taken while the engineer is present and shall be from material produced to meet a specific specification and intended for a specific use.

**1001.12.5** Only approved ledges shall be used in the manufacture of the final product. Approval for use as [Sec 1005](#) portland cement concrete pavement coarse aggregate constitutes approval for all other uses. Approval for use as [Sec 1005](#) portland cement concrete masonry coarse aggregate constitutes approval for all uses, except for portland cement concrete pavement. Approval for use as [Sec 1002](#) asphaltic concrete coarse aggregate constitutes approval for all other uses except for any portland cement concrete product.

**1001.13 Mining By-Product Aggregates.** Aggregates produced as a by-product from lead or zinc mining operations may be furnished under the following requirements. No blending or dilution of these aggregates with other material will be allowed in order to comply with these specifications.

**1001.13.1** The supplier shall separate out all aggregate to be furnished into individual stockpiles not exceeding 5000 cubic yards (4000 m<sup>3</sup>) each. No material will be accepted that has not been moved at least once to a stockpile area specifically for this purpose. The supplier shall randomly sample each stockpile by combining several small samples from the pile into one sample. The sample shall be tested by an approved laboratory for the required lead tests specified in [Sec 1001.13.2](#). A minimum of one set of tests shall be performed for each individual stockpile.

**1001.13.2** For aggregate not encapsulated in asphalt or portland cement mixtures and delivered to MoDOT construction projects or property, the concentration of leachable lead in the aggregate as determined by Method 1311, Toxicity Characteristics Leaching Procedures (TCLP), 40 CFR 261, Appendix II, shall be less than 3.0 ppm, and the total lead content shall be less than 500 ppm as determined by EPA Method 3050A, Acid Digestion of Sediments, Sludges, and Soils (particle size reduced to 1 mm or less). For each individual aggregate meeting [Secs 1002, 1004 and 1005](#) which is encapsulated in asphalt or portland cement mixtures and delivered to MoDOT construction projects or property, there will be no limit on the leachable lead, but the total lead content shall be less than 4,500 ppm. No lead tests are required, and there are no limits on leachable or total lead content, for asphalt or portland cement materials milled from MoDOT projects and reprocessed into a mixture for re-use on MoDOT projects.

**1001.13.3** Prior to any approval, shipment or use of this material, the supplier shall furnish the engineer a report of the laboratory test results. The report shall specifically identify the stockpile, estimated quantity, location, date of sample, date of test and the specific test results for each lead test. Attached to the report shall be a certification from the supplier that the material being furnished does not exceed the lead amounts specified. The supplier shall test as necessary beyond the requirements of this specification to ensure that this specification is met. All costs for setting the material aside for testing and the testing shall be borne by the supplier.

**1001.14 Dust Suppressants.** Approved dust suppressant additives may be used during the crushing or aggregate handling process, provided there is no detrimental effect to the aggregate or subsequent products made from the affected aggregates.

**1001.14.1 Manufacturer and Brand Name Approval.** Prior to approval and use of a dust suppressant additive, the manufacturer shall submit to the Division Engineer, Materials, a certified test report from an approved independent testing laboratory showing specific test results when tested in accordance with MoDOT Test Method T62. The certified test report shall contain the manufacturer's name, brand name of material, date tested, date of

manufacture and dosage rate of the additive used. In addition the manufacturer shall submit to the Division Engineer, Materials, a sample representing the additive tested by the independent testing laboratory and accompanied by a material data sheet, a material safety data sheet showing the brand name, composition or description of the product, the normal and maximum recommended dosage rates, the manner of identification on containers and a copy of the infrared spectrum. The manufacturer shall certify that the material, when used at or below the maximum dosage rate, does not affect the properties of the aggregate or subsequent products made from the treated aggregate. The manufacturer shall also guarantee that as long as the material is furnished under that brand and designation, the material will be of the same composition as originally approved and will in no way be altered or changed. Upon approval of the additive, the manufacturer and brand name will be placed on a list of prequalified dust suppressant additives for aggregates.

**1001.14.2** The aggregate supplier shall keep the inspector advised of the use of any dust suppressant material and provide for the inspection of such facilities. No dust suppressant shall be applied above the manufacturer's maximum recommended rate.

## SECTION 1002

### AGGREGATE FOR ASPHALTIC CONCRETE

#### 1002.1 Coarse Aggregate.

**1002.1.1** All coarse aggregate shall consist of sound, durable rock, free from cemented lumps or objectionable coatings. When tested in accordance with AASHTO T 96, the percentage of wear shall not exceed 50. The percentage of deleterious substances shall not exceed the following values and the sum of percentages of all deleterious substances shall not exceed 8.0 percent.

Percent by Weight (Mass)	
Deleterious Rock	8.0
Shale	1.0
Other Foreign Material	0.5

The requirements of this section apply to each size or fraction of aggregate produced.

**1002.1.1.1** At least 60 percent of the particles retained on a No. 4 (4.75 mm) sieve, for use in bituminous mixtures meeting [Sec 403](#) requirements, shall have two or more mechanically induced faces.

**1002.1.1.2** If a density requirement is specified for asphaltic concrete, the total quantity of chert in each size or fraction of produced crushed stone aggregate, including that permitted as deleterious, shall not vary more than 10 percentage points from the quantity present in the aggregates used in the approved laboratory job mixtures.

**1002.1.2** Crushed stone shall be obtained from rock of uniform quality. Rock tested from individual ledges for preliminary source approval shall meet the following criteria.

Los Angeles Abrasion, AASHTO T 96, percent loss, max	50
Reinforcing Steel for Concrete	4.0

**1002.1.3** Gravel shall meet the following criteria for preliminary or final approval.

Los Angeles Abrasion, AASHTO T 96, percent loss, max	50
Reinforcing Steel for Concrete	5.5

**1002.1.3.1** Gravel aggregate shall be washed sufficiently to remove any objectionable coating. Gravel aggregate for use in bituminous mixtures meeting [Sec 403](#) requirements shall be crushed from gravel that has no more than 10 percent passing the maximum sieve size for the mixture in which the aggregate is intended. Crushed gravel shall comply with the requirements for mechanically induced faces in [Sec 1002.1.1.1](#).

**1002.1.4** Pile-run chat will not be approved for use in asphaltic concrete unless the chat has been conditioned to meet a specific gradation. A tolerance not to exceed 7 percent on each sieve fraction will be permitted provided the aggregate complies with other provisions of this specification.

**1002.1.5** Coarse aggregate for Type I-B asphaltic concrete mixtures shall be furnished and stockpiled in two or more separate sizes or fractions. One fraction shall consist of material retained on the 1/2-inch (12.5 mm) sieve, and the other fractions shall consist of material passing the 1/2-inch (12.5 mm) sieve. A tolerance not to exceed 25 percent may be permitted on the 1/2-inch (12.5 mm) sieve for each fraction.

**1002.1.6** Crushed porphyry aggregate meeting the approval of the engineer shall be a uniform product, furnished in one or more fractions. The total crushed porphyry aggregate shall be uniformly graded and shall have material passing each sieve from the maximum size aggregate through the No. 200 (75  $\mu$ m) sieve. Total aggregate gradations consisting of essentially one size aggregate will not be permitted.

**1002.1.7** Crushed steel slag aggregate meeting the approval of the engineer shall be a uniform product, furnished in one or more fractions. Steel slag consisting principally of a fused mixture of oxides and silicates is a synthetic aggregate produced as a by-product of basic oxygen, electric or open hearth steel making furnaces. The steel slag shall be aged at least three months after crushing and screening. Material that is screened after the steel slag has been crushed, initially and aged three months will not be required to receive additional aging. Steel slag from one source shall not be mixed with or used with steel slag from a different source. The total crushed steel slag aggregate shall be uniformly graded and shall have material passing each sieve from the maximum size aggregate through the No. 200 (75  $\mu$ m) sieve. Total aggregate gradations consisting of essentially one size aggregate will not be permitted.

**1002.1.8** The gradation of coarse aggregate shall be such that the combinations of coarse aggregate fractions, when combined with fine aggregate, will meet the gradation requirements for the type of asphaltic concrete specified. All fractions of coarse aggregate shall comply with the following requirements, with the exception of crushed porphyry and crushed steel slag. The maximum size of each fraction is defined by the smallest sieve through which 100 percent will pass:

Maximum Size of Fraction	Maximum Percent Passing	
	No. 8 (2.36 mm) Sieve	No. 200 (75 $\mu$ m) Sieve
1 inch (25.0 mm)	....	2.0
3/4 inch (19.0 mm)	12.0	3.5
1/2 inch (12.5 mm)	12.0	3.5
3/8 inch (9.5 mm) or smaller	14.0	4.0

## **1002.2 Fine Aggregate.**

**1002.2.1** Fine aggregate for asphaltic concrete shall be a fine, granular material naturally produced by the disintegration of rock of a siliceous nature and/or manufactured by the mechanical reduction of sound durable rock with a percentage of wear not exceeding 50 when tested in accordance with AASHTO T 96. With written approval of the engineer and compliance with this specification, chat sand produced from flint chat in the Joplin area, dolomite chat as produced in the southeast lead belt area or fines manufactured from igneous rock and chert gravel or wet bottom boiler slag may be used as fine aggregate for asphaltic concrete. Fine aggregate shall be free from cemented or conglomerated lumps and shall not have any coating or injurious material. The fraction passing a No. 40 (425  $\mu$ m) sieve shall be non-plastic. The percentage of deleterious substances shall not exceed the following values:

Item	Percent by Weight (Mass)
Clay lumps and shale	1.0
Total lightweight (low mass density) particles, including coal and lignite	0.5
Other deleterious substances	0.1

Lightweight (Low mass density) sand particles are not considered deleterious lightweight (low mass density) particles. The total lightweight (low mass density) particles requirement shall not apply to wet bottom boiler slag, angular chert sand or manufactured sand.

**1002.2.2** Natural aggregate delivered to the cold bin shall be furnished in one fraction and shall meet the following gradation requirements. If the material is produced by use of two or more fractions, they shall be thoroughly blended at the site of original mixing to form a single material of uniform gradation. Further, if the blending is performed at the job site, it shall be done a sufficient distance from the cold feed bins so that the blended stockpile of fine aggregate will be moved at least once before being fed into the cold bin.

Sieve Size	Percent Passing by Weight (Mass)
3/8 inch (9.5 mm)	100
No. 200 (75 µm)	0-6

**1002.2.3** Fine aggregate manufactured by the mechanical reduction of sound durable rock shall be delivered to the cold feed in one fraction, separate from any natural fine aggregate and shall meet the following gradation requirements.

Sieve Size	Percent Passing by Weight (Mass)
3/8 inch (9.5 mm)	100
No. 4 (4.75 mm)	85-100
No. 200 (75 µm)	0-8

**1002.3 Mineral Filler.** Mineral filler shall consist of limestone dust, portland cement or other suitable mineral matter. Mineral filler shall be thoroughly dry and free of lumps consisting of aggregations of fine particles. When tested in accordance with AASHTO T 37 the mineral filler shall conform to the following gradation requirements:

Sieve Size	Percent Passing by Weight (Mass)
No. 30 (600 µm)	100
No. 50 (300 µm)	95-100
No. 100 (150 µm)	90-100
No. 200 (75 µm)	70-100

**1002.4 Hydrated Lime.** Hydrated lime shall be thoroughly dry and free of lumps. Hydrated lime produced from limestone shall comply with ASTM C 206, Type N or S. Hydrated lime produced from dolomite shall comply with ASTM C 206, Type S. The plasticity requirements of ASTM shall not apply to either Type N or S, and the gradation shall be determined in accordance with AASHTO T 37.

## SECTION 1003

### AGGREGATE FOR SEAL COATS

**1003.1** Aggregate for seal coats shall consist of sound durable rock particles, free from objectionable coatings. When tested in accordance with AASHTO T 96, the percentage of wear shall not exceed 50. The percentage of deleterious substances shall not exceed the following values and the sum of percentages of all deleterious substances shall not exceed 8.0 percent.

Percent by Weight (Mass)	
Deleterious Rock	8.0
Shale	1.0
Other Foreign Material	0.5

**1003.1.1** Crushed stone shall be obtained from rock of uniform quality. Rock from individual ledges and gravel tested for preliminary source approval shall meet the following criteria.

Absorption, AASHTO T 85, percent, max	6.0
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**1003.2** The aggregate shall comply with the following requirements for the grade specified in the contract:

ENGLISH							
Grade	Kind of Material	Percent Passing by Weight					
		Sieve Sizes					
		1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 10
1	Crushed Stone	100	90-100	....	30-65	....	0-5
2	Crushed Stone, Gravel or Chat	....	100	90-100	30-65	0-5	....
3	Crashed Stone, Gravel or Chat	....	....	100	80-100	0-5	....
4	Crushed Stone, Gravel or Chat	....	....	100	80-100	....	0-5
5	Crushed Stone, Gravel or Chat	....	....	100	80-95	....	0-10
6	Crushed Stone, Gravel or Chat	....	....	100	90-100	....	0-15
7	Crushed Stone, Gravel or Chat	....	....	100	95-100	....	0-5
8	Gravel or Chat	....	....	....	100	45-85	0-10



METRIC							
Grade	Kind of Material	Percent Passing by Mass					
		Sieve Sizes					
		25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.00 mm
1	Crushed Stone	100	90-100	....	30-65	....	0-5
2	Crushed Stone, Gravel or Chat	....	100	90-100	30-65	0-5	....
3	Crashed Stone, Gravel or Chat	....	....	100	80-100	0-5	....
4	Crushed Stone, Gravel or Chat	....	....	100	80-100	....	0-5
5	Crushed Stone, Gravel or Chat	....	....	100	80-95	....	0-10
6	Gravel or Chat	....	....	100	90-100	....	0-15
7	Crushed Stone, Gravel or Chat	....	....	100	95-100	....	0-5
8	Gravel or Chat	....	....	....	100	45-85	0-10

## SECTION 1004

### GRADED AGGREGATE FOR BITUMINOUS SURFACE

**1004.1** Graded aggregate for bituminous surface shall consist of sound, durable rock particles, free from objectionable coatings. When tested in accordance with AASHTO T 96, the percentage of wear shall not exceed 55. The percentage of deleterious substances shall not exceed the following values and the sum of percentages of all deleterious substances shall not exceed 8.0 percent.

Percent by Weight (Mass)	
Deleterious Rock	8.0
Mud Balls and Shale Combined	2.0
Clay, uniformly dispersed	3.0
Other Foreign Material	0.5

**1004.1.1** Crushed stone shall be obtained from rock of uniform quality. Rock from individual ledges and gravel tested for preliminary source approval shall meet the following criteria:

Absorption, AASHTO T 85, percent, max	7.0
---------------------------------------	-----

**1004.2** The aggregate shall comply with the following requirements for the grade specified in the contract. If grade is not specified, any listed grade may be used.

ENGLISH								
Grade	Kind of Material	Percent Passing						
		Sieve Sizes						
		3/4 in.	1/2 in.	3/8 in.	#4	#8	#30	#200
A	Crushed Stone or Porphyry	100	95-100	65-95	20-55	2-20	....	0-5
B	Gravel	100	95-100	....	40-80	15-50	0-30	0-5
C	Chat	100	95-100	....	45-85	30-60	0-30	0-5
D	Chat	100	95-100	75-100	30-65	15-30	0-20	0-5
METRIC								
Grade	Kind of Material	Percent Passing						
		Sieve Sizes						
		19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	600 µm	75 µm
A	Crushed Stone or Porphyry	100	95-100	65-95	20-55	2-20	....	0-5
B	Gravel	100	95-100	....	40-80	15-50	0-30	0-5
C	Chat	100	95-100	....	45-85	30-60	0-30	0-5
D	Chat	100	95-100	75-100	30-65	15-30	0-20	0-5

## SECTION 1005

### AGGREGATE FOR CONCRETE

#### 1005.1 Coarse Aggregate.

**1005.1.1** All coarse aggregate for concrete shall consist of sound, durable rock, free from objectionable coatings and frozen and cemented lumps. The percentage of deleterious substances shall not exceed the following values and the sum of percentages of all deleterious substances, exclusive of Items 5 and 6, shall not exceed 6.0 percent. For crushed stone, the percentage of wear shall not exceed 50 when tested in accordance with AASHTO T 96.

	Percent by Weight (Mass)
1. Deleterious Rock	6.0
2. Shale	1.0
3. Chert in Limestone	4.0
4. Other Foreign Material	0.5
5. Material Passing No. 200 (75 µm) Sieve	
a. Coarse Fraction, Limestone, Gradation A	1.5
b. Fine Fraction, Limestone, Gradation A	2.5
c. Limestone, Gradations B, D, & E	2.0
d. Limestone, Gradation F	2.5
e. Other Aggregates	1.0
6. Thin or Elongated Pieces	5.0

The above requirements apply to each size or fraction of aggregate produced.

**1005.1.1.1** Crushed stone shall be obtained from rock of uniform quality. Except as noted herein, rock tested from individual ledges for preliminary source approval shall meet the following criteria:

Log Angeles Abrasion, AASHTO T 96, percent loss, max	50
Absorption, AASHTO T 85, percent, max.:	
Portland Cement Concrete Pavement	2.0*
Portland Cement Concrete Masonry	3.5
Soundness, MoDOT Test Method T 14, percent loss, max.:	
Portland Cement Concrete Pavement	16.0
Portland Cement Concrete Masonry	18.0

\* If an individual ledge or ledges in a production face constitutes 15 percent or less of the total thickness of the production face height being used to produce the final product, the absorption for that individual ledge or ledges may exceed the maximum limit specified by 0.5 percentage points.

**1005.1.1.2** Crushed stone for portland cement concrete pavement, base and approach slabs for bridges, from sources required to conform to Gradation F, shall be from individual ledges having preliminary approval under the following criteria:

Log Angeles Abrasion, AASHTO T 96, percent loss, max	50
Absorption, AASHTO T 85, percent, max.	1.5
Soundness, MoDOT Test Method T 14, percent loss, max.	10.0
Bulk Specific Gravity, AASHTO T 85, min.	2.58

**1005.1.1.3** Gravel shall be washed and shall meet the following for preliminary and final approval:

Log Angeles Abrasion, AASHTO T 96, percent loss, max	45
Absorption, AASHTO T 85, percent, max.	4.5
Soundness, MoDOT Test Method T 14, percent loss, max.	18.0

**1005.1.1.4** The engineer reserves the right to also use additional test methods such as ASTM C 586, AASHTO T 161, AASHTO T 104 or other appropriate tests to measure the soundness and durability of aggregates for use in concrete when deemed necessary.

**1005.1.2** Coarse aggregate for concrete pavement or base course shall be crushed stone or porphyry and may be furnished, handled and batched in two separate sizes or fractions or in one size or fraction, as herein specified.

**1005.1.2.1** If coarse aggregate for concrete pavement or base is furnished, handled and batched in two separate sizes or fractions, one fraction shall consist of material retained on the 3/4-inch (19.0 mm) sieve, and the other fraction shall consist of material passing the 3/4-inch (19.0 mm) sieve. A tolerance not to exceed 15 percent may be permitted on the 3/4-inch (19.0 mm) sieve for each fraction. The two fractions will be combined in a ratio as near as possible to the proportions in which the two fractions are furnished by the contractor to make a uniformly well-graded coarse aggregate graded within the following limits:

<b>Gradation A</b>	<b>Percent by Weight (Mass)</b>
Passing 2-inch (50 mm) sieve	100
Passing 1 1/2-inch (37.5 mm) sieve	95-100
Passing 3/4-inch (19.0 mm) sieve	35-70
Passing 3/8-inch (9.5 mm) sieve	10-30
Passing No. 4 (4.75 mm) sieve	0-5

Coarse aggregate may be divided into more than two fractions if approved by the engineer.

**1005.1.2.2** If crushed flint is used as coarse aggregate, the crushed flint shall meet the above requirements, and in addition 100 percent shall pass the 1 1/2-inch (37.5 mm) sieve.

**1005.1.2.3** The contractor shall be responsible for maintaining the proper balance in the quantities of each fraction and for securing the final quantities of each fraction in such proportions as to minimize wastage.

**1005.1.2.4** If coarse aggregate for concrete pavement or base is furnished, handled and batched in one size or fraction, the aggregate shall be graded to meet Gradation B, as follows or Gradation D, [Sec 1005.1.3](#) except when Gradation F is required as defined in [Sec 1005.1.2.5](#).

<b>Gradation B</b>	<b>Percent by Weight (Mass)</b>
Passing 1 1/2-inch (37.5 mm) sieve	100
Passing 1-inch (25.0 mm) sieve	95-100
Passing 1/2-inch (12.5 mm) sieve	25-60
Passing No. 4 (4.75 mm) sieve	0-8

**1005.1.2.5** Coarse aggregate for portland cement concrete pavement, base and approach slabs for bridges which is not produced from the Burlington, Keokuk, Cedar Valley (formerly Callaway) or Warsaw limestone formations which is obtained from sources in the following areas shall be graded to conform to Gradation F.

(a) State of Kansas, Iowa and Nebraska.

(b) Counties of Missouri - Adair, Andrew, Atchison, Bates, Benton, Buchanan, Caldwell, Carroll, Cass, Cedar, Chariton, Clay, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Henry, Holt, Jackson, Johnson, Lafayette, Linn, Livingston, Mercer, Macon, Nodaway, Pettis, Platte, Putnam, Randolph, Ray, St. Clair, Saline, Schuyler, Sullivan, Vernon and Worth.

<b>Gradation F</b>	<b>Percent by Weight (Mass)</b>
Passing 1/2-inch (12.5 mm) sieve	100
Passing 3/8-inch (9.5 mm) sieve	85-100
Passing No. 4 (4.75 mm) sieve	10-30
Passing No. 8 (2.36 mm) sieve	0-10
Passing No. 16 (1.18 mm) sieve	0-5

**1005.1.3** Coarse aggregate for concrete for structures, except as specified in [Sec 1005.1.4](#), may be gravel or crushed stone. Coarse aggregate for Class B, B-1, B-2 or Seal concrete shall meet the requirements of either Gradation D or E. Coarse aggregate for Class A-1 concrete shall meet the requirements of Gradation E.

<b>Gradation D</b>	<b>Percent by Weight (Mass)</b>
Passing 1-inch (25.0 mm) sieve	100
Passing 3/4-inch (19.0 mm) sieve	90-100
Passing 3/8-inch (9.5 mm) sieve	15-45
Passing No. 4 (4.75 mm) sieve	0-8

<b>Gradation E</b>	<b>Percent by Weight (Mass)</b>
Passing 3/4-inch (19.0 mm) sieve	100
Passing 1/2-inch (12.5 mm) sieve	80-100
Passing 3/8-inch (9.5 mm) sieve	40-70
Passing No. 4 (4.75 mm) sieve	0-10
Passing No. 8 (2.36 mm) sieve	0-4

**1005.1.4** Coarse aggregate for ornamental concrete shall be crushed stone meeting the requirements of [Sec 1005.1.3](#), Gradation E. However, the use of coarse aggregate containing more than 2 percent chert will not be permitted.

## 1005.2 Fine Aggregate.

**1005.2.1** Fine aggregate for concrete shall be a fine granular material naturally produced by the disintegration of rock of a siliceous nature or manufactured from an approved limestone or dolomite source as defined in [Sec 1005.1](#). By specific approval of the engineer, chat sand produced from flint chat in the Joplin area or fines manufactured from igneous rock or chert gravel may be used. Fine aggregate shall be free from cemented or conglomerated lumps and shall not have any coating of injurious material. The percentage of deleterious substances shall not exceed the following values:

	Percent by Weight (Mass)
Clay Lumps and Shale	0.25
Coal and Lignite	0.25
Total Lightweight (low mass density) Particles, Including Coal and Lignite	0.50
Material Passing No. 200 (75 $\mu$ m) Sieve	
a. Natural Sand	2.0
b. Manufactured Sand	4.0
Other Deleterious Substances	0.10

Lightweight (Low mass density) sand particles are not considered deleterious lightweight (low mass density) particles. The total lightweight (low mass density) particle requirement shall not apply to angular chert sand or manufactured sand.

**1005.2.2** Fine aggregate subjected to the mortar strength test shall produce a mortar having a tensile strength at the age of 7 days of at least 90 percent of that developed at the same age by mortar of the same proportions and consistency made of the same cement and Standard Ottawa sand. Tests shall be made in accordance with AASHTO T 132. Cement used in the tests shall be Type I meeting the requirements of [Sec 1019](#).

**1005.2.2.1** Fine aggregate subjected to the colorimetric test for organic impurities and producing a color darker than the standard will be rejected unless compliance with the mortar strength test specified in [Sec 1005.2.2](#) is met.

**1005.2.3** Fine aggregate for ornamental concrete shall be free from coal and lignite material when tested in accordance with AASHTO T 113.

## 1005.2.4 Gradation.

**1005.2.4.1** All fine aggregate shall meet the following gradation requirements:

	Percent by Weight (Mass)
Passing 3/8-inch (9.5 mm) sieve	100
Passing No. 4 (4.75 mm) sieve	95-100
Passing No. 20 (850 $\mu$ m) sieve	40-75
Passing No. 50 (300 $\mu$ m) sieve	5-30
Passing No. 100 (150 $\mu$ m) sieve	0-10

### 1005.3 Lightweight (Low Mass Density) Aggregates.

**1005.3.1** Lightweight (Low mass density) aggregates shall be prepared by expanding, calcining or sintering argillaceous material such as clay, shales and slates.

**1005.3.2 Grading.** The grading shall be uniform and conform to the requirements given in Table I.

**1005.3.3 Unit Weight (Mass).** The unit weight (mass) of lightweight (low mass density) aggregates shall not exceed the following:

<b>Dry, Loose Weight (Mass), Max, lb per cu ft (kg/m<sup>3</sup>)</b>	
Fine Aggregate	70 (1120)
Coarse Aggregate	55 (880)

**1005.3.3.1 Uniformity of Weight (Mass).** If the unit weight (mass) of any shipment of lightweight (low mass density) aggregate when tested in accordance with AASHTO T 19 is found to vary by more than 10 percent from that of the sample submitted for source approval, the aggregate in the shipment may be rejected.

**1005.3.4 Soundness.** When tested in accordance with AASHTO T 104, the loss of lightweight (low mass density) fine or coarse aggregate in 5 cycles of the accelerated soundness test shall not exceed 8 percent if sodium sulfate is used or 10 percent if magnesium sulfate is used.

**1005.3.5 Drying Shrinkage.** The drying shrinkage of concrete specimens prepared and tested in accordance with Section 9.1.4 of AASHTO M 195, shall not exceed 0.07 percent.

**1005.3.6 Sampling.** Samples of fine and coarse aggregate shall be furnished by the contractor for source approval. Other samples shall be taken from shipments at intervals specified by the engineer.





TABLE I											
Grading Requirements for Lightweight Aggregate											
ENGLISH											
Grade	Size	Percent Passing									
		Sieve Sizes									
		1 1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 8	No. 16	No. 50	No. 100
	Fine Aggregate No. 4 to 0	....	....	....	....	100	85-100	....	40-80	10-35	5-20
1	Coarse Aggregate 1" to 1/2"	100	90-100	20-55	0-10	0-5	....	....	....	....	....
2	1" to No. 4	100	95-100	....	25-60	....	0-10	0-5	....	....	....
3	3/4" to No. 4	....	100	90-100	....	20-55	0-10	0-5	....	....	....
4	1/2" to No. 4	....	....	100	90-100	40-70	0-15	0-5	....	....	....
5	3/8" to No. 8	....	....	....	100	85-100	10-30	0-10	0-5	....	....
METRIC											
Grade	Size	Percent Passing									
		Sieve Sizes									
		37.5 mm	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	300 µm	150 µm
	Fine Aggregate 4.75 to 0	....	....	....	....	100	85-100	....	40-80	10-35	5-20
1	Coarse Aggregate 25.0 to 12.5	100	90-100	20-55	0-10	0-5	....	....	....	....	....
2	25.0 to 4.75	100	95-100	....	25-60	....	0-10	0-5	....	....	....
3	19.0 to 4.75	....	100	90-100	....	20-55	0-10	0-5	....	....	....
4	12.5 to 4.75	....	....	100	90-100	40-70	0-15	0-5	....	....	....
5	9.5 to 2.36	....	....	....	100	85-100	10-30	0-10	0-5	....	....



## SECTION 1006

### AGGREGATE FOR SURFACING

**1006.1** Aggregate for surfacing shall be composed of durable particles of rock. When tested in accordance with AASHTO T 96, the percentage of wear shall not exceed 60. The percentage of deleterious substances shall not exceed the following values and the sum of percentages of all deleterious substances shall not exceed 12 percent.

Percent by Weight (Mass)	
Deleterious Rock and Shale	12.0
Mud Balls	5.0
Other Foreign Material	2.0

**1006.2** The aggregate shall comply with the following requirements for the grade specified in the contract:

ENGLISH							
Grade	Kind of Material	Percent Passing					
		Sieve Sizes					
		1 in.	3/4 in.	3/8 in.	No. 4	No. 10	No. 200
A	Gravel	100	80-100	....	*60	10-35	0-10
B	Crushed Stone	100	....	*65	....	5-25	....
C	Chat	100	....	....	*80	*45	....
D	Gravel	....	100	....	*75	10-40	....
E	Gravel	....	100	....	*75	10-40	0-5
F	Crushed Stone	....	100	*75	....	10-30	....
G	Crushed Stone or Gravel	....	100	*75	....	0-15	....
METRIC							
Grade	Kind of Material	Percent Passing					
		Sieve Sizes					
		25.0 mm	19.0 mm	9.5 mm	4.75 mm	2.00 mm	75 µm
A	Gravel	100	80-100	....	*60	10-35	0-10
B	Crushed Stone	100	....	*65	....	5-25	....
C	Chat	100	....	....	*80	*45	....
D	Gravel	....	100	....	*75	10-40	....
E	Gravel	....	100	....	*75	10-40	0-5
F	Crushed Stone	....	100	*75	....	10-30	....
G	Crushed Stone or Gravel	....	100	*75	....	0-15	....

\* Indicates maximum permitted.

## SECTION 1007

### AGGREGATE FOR BASE

**1007.1 Type 1 Aggregate.** Type 1 aggregate for base shall be essentially limestone or dolomite. The aggregate shall not contain more than 15 percent deleterious rock and shale. Sand may be added only for the purpose of reducing the plasticity index of the fraction passing the No. 40 (425  $\mu$ m) sieve in the finished product. Any sand, silt and clay and any deleterious rock and shale shall be uniformly distributed throughout the material. The aggregates shall conform to the following gradation requirements:

	Percent by Weight (Mass)
Passing 1-inch (25.0 mm) sieve	100
Passing 1/2-inch (12.5 mm) sieve	60-90
Passing No. 4 (4.75 mm) sieve	40-60
Passing No. 40 (425 $\mu$ m) sieve	15-35

The fraction passing the No. 40 (75  $\mu$ m) sieve shall have a plasticity index not to exceed six.

**1007.2 Type 2 Aggregate.**

**1007.2.1** Type 2 aggregate for base shall consist of crushed stone, sand and gravel or chat, with or without soil binder as may be required to conform to the requirements of these specifications. If crushed stone is used, sand may be added only for the purpose of reducing the plasticity index of the fraction passing the No. 40 (425  $\mu$ m) sieve in the finished product. The aggregate shall not contain more than 15 percent deleterious rock and shale. Deleterious rock, shale, sand or binder if required, shall be uniformly distributed throughout the material. The aggregate, combined with binder if required, shall conform to one of the following gradation requirements:

	Percent by Weight (Mass)	
	Gradation A	Gradation B
Passing 1-inch (25.0 mm) sieve	100	....
Passing 3/4-inch (19.0 mm) sieve	....	100
Passing 1/2-inch (12.5 mm) sieve	60-90	....
Passing No. 4 (4.75 mm) sieve	40-60	55-85
Passing No. 10 (2.00 mm) sieve	....	40-65
Passing No. 40 (425 $\mu$ m) sieve	15-35	20-45

The fraction passing the No. 200 (75  $\mu$ m) sieve shall, when sand and gravel aggregate is used, be less than 2/3 of the fraction passing the No. 40 (425  $\mu$ m) sieve. The fraction passing the No. 40 (425  $\mu$ m) sieve shall have plasticity indices as follows:

	Minimum	Maximum
Crushed Stone or Chat	0	6
Sand and Gravel	2	6

**1007.2.2** Binder shall consist of soil or similar fine material with such cohesive properties as to impart the desired plasticity to the finished base course. The binder shall be obtained from a source approved by the engineer.

### 1007.3 Type 3 Aggregate.

**1007.3.1** Type 3 aggregate for base shall consist of crushed stone, limestone screenings, sand and gravel, sand, chat or sandstone or combinations of these materials, with or without soil binder as may be required. The aggregate shall contain not more than 15 percent deleterious rock and shale. The material shall conform to the following gradation requirements and in addition shall be so graded that the aggregate will readily compact to the specified density and withstand construction traffic without distortion and displacement.

	Percent by Weight (Mass)
Passing 1 1/2-inch (37.5 mm) sieve	100
Passing No. 40 (425 µm) sieve	15-50
Passing No. 200 (75 µm) sieve	0-35

The fraction passing the No. 40 (425 µm) sieve for Type 3 aggregate shall have a plasticity index not to exceed eight. If chat is used, the chat shall meet the requirements of this section and in addition shall have a minimum of 20 percent passing the No. 40 (425 µm) sieve. If soft sandstone, sand or sand-gravel mixtures are used, they shall meet the requirements of this section and in addition the fraction passing the No. 40 (425 µm) sieve shall have a plasticity index not less than two nor greater than eight.

**1007.3.2** Binder shall consist of soil or similar fine material with such cohesive properties as to impart the desired plasticity to the finished product. The binder shall be obtained from a source approved by the engineer.

### 1007.4 Type 4 Aggregate.

**1007.4.1** Type 4 aggregate for base shall consist of a uniform mixture of washed sand and gravel, crushed stone or chat. Aggregates shall consist of sound durable particles. When tested in accordance with AASHTO T 96, the percentage of wear shall not exceed 55. The percentage of deleterious substances shall not exceed the following values and the sum of these percentages shall not exceed 8 percent.

	Percent by Weight (Mass)
Deleterious Rock	8.0
Shale and Mud Balls	4.0

The material shall at all times during loading, hauling and placing, contain sufficient moisture to prevent segregation and to aid in obtaining compaction.

**1007.4.2** Washed sand and gravel mixtures shall meet the following gradation requirements:

	<b>Percent by Weight (Mass)</b>
Passing 1-inch (25.0 mm) sieve	100
Passing 1/2-inch (12.5 mm) sieve	55-90
Passing No. 10 (2.00 mm) sieve	25-50
Passing No. 40 (425 $\mu$ m) sieve	10-30
Passing No. 100 (150 $\mu$ m) sieve	0-10
Passing No. 200 (75 $\mu$ m) sieve	0-3

**1007.4.3** Crushed stone shall consist of limestone or dolomite and shall meet the following gradation requirements:

	<b>Percent by Weight (Mass)</b>
Passing 1-inch (25.0 mm) sieve	100
Passing 1/2-inch (12.5 mm) sieve	55-90
Passing No. 4 (4.75 mm) sieve	8-40
Passing No. 10 (2.00 mm) sieve	0-15
Passing No. 200 (75 $\mu$ m) sieve	0-4

A tolerance not to exceed 2 percent passing the No. 200 (75  $\mu$ m) sieve will be permitted for samples taken at the point of delivery on the roadway.

**1007.4.4** Chat shall meet the following gradation requirements:

	<b>Percent by Weight (Mass)</b>
Passing 3/4-inch (19.0 mm) sieve	100
Passing 1/2-inch (12.5 mm) sieve	90-100
Passing No. 10 (2.00 mm) sieve	20-50
Passing No. 40 (425 $\mu$ m) sieve	5-30
Passing No. 200 (75 $\mu$ m) sieve	0-5

#### **1007.5 Type 5 Aggregate.**

**1007.5.1** Type 5 aggregate for base shall consist of crushed stone or sand and gravel. The aggregate shall not contain more than 15 percent deleterious rock and shale. If crushed stone is used, sand may be added only for the purpose of reducing the plasticity index of the fraction passing the No. 40 (425  $\mu$ m) sieve in the finished product. The fraction passing the No. 40 (425  $\mu$ m) sieve shall have a plasticity index not to exceed six. Any sand, silt and clay and any deleterious rock and shale shall be uniformly distributed throughout the material. When sand and gravel aggregate is used, the fraction passing the No. 200 (75  $\mu$ m) sieve shall be less than 1/2 that of the fraction passing the No. 30 (600  $\mu$ m) sieve.

**1007.5.2** Type 5 aggregate shall conform to the following gradation requirements and in addition shall be so graded that the aggregate will readily compact to the specified density and withstand construction traffic without distortion and displacement.

	<b>Percent by Weight (Mass)</b>
Passing 1-inch (25.0 mm) sieve	100
Passing 1/2-inch (12.5 mm) sieve	60-90
Passing No. 4 (4.75 mm) sieve	40-60
Passing No. 30 (600 $\mu$ m) sieve	15-35
Passing No. 200 (75 $\mu$ m) sieve	0-15

## SECTION 1009

### AGGREGATE FOR DRAINAGE

**1009.1 Scope.** This specification covers material requirements for aggregate as specified for various drainage systems.

**1009.2** All aggregates shall meet the quality requirements of [Sec 1002](#) and be of the material and gradation specified herein.

**1009.2.1 Grade 1.** The aggregate shall be sand meeting the gradation requirements of [Sec 1005.2](#).

**1009.2.2 Grade 2.** The aggregate shall be a washed sand-gravel mixture meeting the gradation requirements for [Sec 1007.4.2](#).

**1009.2.3 Grade 3.** The aggregate shall be gravel, crushed stone or other approved material meeting one of the following gradation requirements for [Sec 1005.1](#), Gradation A , B, D or E.

**1009.2.4 Grade 4.** The aggregate shall be a crushed limestone or dolomite meeting the following gradation requirements. Unless otherwise specified, either gradation may be used.

Gradation A	
Sieve Size	Percent by Weight (Mass)
1 1/2-inch (37.5 mm)	100
1-inch (25.0 mm)	95-100
1/2-inch (12.5 mm)	25-60
No. 4 (4.75 mm)	0-10
No. 8 (2.36 mm)	0-5

Gradation B	
Sieve Size	Percent by Weight (Mass)
1-inch (25.0 mm)	100
3/4-inch (19.0 mm)	90-100
3/8-inch (9.5 mm)	20-55
No. 4 (4.75 mm)	0-10
No. 8 (2.36 mm)	0-5

**1009.2.5 Grade 5.** The aggregate shall be a crushed limestone or dolomite meeting the following gradation requirements:



<b>Sieve Size</b>	<b>Percent by Weight (Mass)</b>
1 1/2-inch (37.5 mm)	100
1-inch (25.0 mm)	95-100
1/2-inch (12.5 mm)	60-80
No. 4 (4.75 mm)	40-55
No. 8 (2.36 mm)	5-25
No. 16 (1.18 mm)	0-8
No. 50 (300 $\mu$ m)	0-5

## SECTION 1011

### GEOTEXTILE

**1011.1 Scope.** This specification covers geotextile for use in subsurface drainage, sediment control, erosion control or as a permeable separator.

**1011.2 Material.** Geotextiles shall meet the physical and chemical requirements of AASHTO M 288 for the specified application except as modified herein.

#### **1011.2.1 General.**

**1011.2.1.1** No specific permeability values are required.

**1011.2.1.2** The U. S. Standard sieve number corresponding to the apparent opening size (AOS) shall not exceed 100 (150  $\mu\text{m}$ ) for geotextile used in contact with any soil with more than 50 percent passing the No. 200 (75  $\mu\text{m}$ ) sieve nor shall the AOS exceed 70 (212  $\mu\text{m}$ ) when used between any two dissimilar granular material, less than 50 percent passing the No. 200 (75  $\mu\text{m}$ ) sieve, or when used to control movement of fines from a granular backfill through structural joints or into a drain pipe.

**1011.2.1.3** During shipment and storage, geotextiles shall be protected from direct sunlight, ultra-violet rays, temperatures greater than 140 F (60 C), mud, dust and debris.

**1011.2.2 Type 1, Subsurface Drainage.** Type 1 geotextile is intended for use in subsurface drainage as a filter to protect drainage media from clogging with fines from adjacent soil. Typical applications include lining of drainage trenches and wrapping drain pipes.

**1011.2.2.1** The minimum permittivity shall be  $1.3 \text{ sec}^{-1}$ .

**1011.2.2.2** The material may be either AASHTO Class A or Class B unless otherwise specified.

**1011.2.2.3** When material is furnished in the form of a knitted or woven sock to be stretched to fit snugly around perforated pipe, the grab strength requirements for AASHTO Class B applications may be reduced by 33 percent provided the minimum elongation is greater than 50 percent.

**1011.2.3 Type 2, Sediment Control.** Type 2 geotextile is intended for use in supported or non-supported sediment control fencing.

**1011.2.4 Type 3, Erosion Control.** Type 3 geotextile is intended for uses such as erosion control of slopes and channels when placed under rock blanket, rock ditch liner, etc.

**1011.2.4.1** The minimum permittivity shall be  $1.0 \text{ sec}^{-1}$ .

**1011.2.4.2** The material may be either AASHTO Class A or Class B unless otherwise specified.

**1011.2.5 Type 4, Separation.** Type 4 geotextile is intended for use as a separation material to prevent mixing of dissimilar material and to control migration of backfill material through joints in structural elements. Typical applications include use between soil and select granular

backfills behind retaining structures, box culvert joint wraps, placement behind mechanically stabilized earth wall facing panels, cover for drainage blankets and soil/rock fill separation in slide repairs.

**1011.2.5.1** The minimum permittivity shall be  $1.0 \text{ sec}^{-1}$ .

**1011.2.5.2** The material may be either high or medium survivability level unless otherwise specified.

**1011.3 Certification and Acceptance.**

**1011.3.1** The contractor shall furnish a manufacturer's certification to the engineer, for each lot of material furnished stating the name of the manufacturer, the chemical composition of the filaments or yarns and certifying that the material supplied conform to all requirements specified. The certification shall include or have attached typical results of tests from specific lots for all specified requirements.

**1011.3.2** Acceptance of the material will be based on the manufacturer's certification and upon the results of such tests as may be performed by the engineer.

## SECTION 1012

### GEOCOMPOSITE DRAINAGE MATERIAL

**1012.1 Scope.** This specification covers material for use as geocomposite drains.

**1012.2 Material.**

**1012.2.1 General.** During shipment and storage, geocomposite material shall be protected from direct sunlight, ultra-violet rays, temperatures greater than 140 F (60 C), mud, dust and debris.

**1012.2.2 Edge Drain.** Edge drain shall consist of a plastic core completely surrounded by geotextile.

**1012.2.2.1** The edge drain shall have nominal dimensions of 1 to 1 1/2 inches (25 to 38 mm) in thickness by 12 inches (300 mm) in height.

**1012.2.2.2** The edge drain shall have a minimum flow capacity of 15 gallons per minute per foot (3 liters/s/m) of width as determined by ASTM D 4716 when tested under a confining stress of 10 psi (69 kPa) or more at a gradient of 0.1 or less.

**1012.2.2.3** The edge drain shall have a minimum compressive strength of either 7,000 psf (335 kPa) at a maximum deformation of 10 percent of the original thickness when tested in accordance with ASTM D 1621 or 8,000 psf (383 kPa) at a maximum deformation of 20 percent when tested in accordance with ASTM D 695.

**1012.2.2.4** The core shall provide a minimum of 10 percent open area to facilitate water entry or cross flow and shall be composed of plastic which is physically and chemically stable under a normal range of service conditions.

**1012.2.2.5** Geotextile shall meet [Sec 1011](#) for Type 1 (Subsurface Drainage) geotextile and have an apparent opening size (AOS) corresponding to a U. S. sieve number greater than 50 (300 µm) but not exceeding 100 (150 µm).

**1012.2.3 Vertical Drain at End Bents.** The vertical drain shall consist of a plastic core with a geotextile attached to one or both sides.

**1012.2.3.1** The vertical drain shall not be less than 3/8 inch (9.5 mm) or greater than 1 inch (25 mm) in thickness.

**1012.2.3.2** The vertical drain shall have a minimum flow capacity of 5 gallons per minute per foot (1 liter/s/m) of width in either principal direction.

**1012.2.3.3** The vertical drain shall have a minimum compressive strength of 6,000 psf (287 kPa) at a maximum deformation of 10 percent of the original thickness when tested in accordance with ASTM D 1621.

**1012.2.3.4** The core shall be composed of plastic which is physically and chemically stable under a normal range of service conditions.

**1012.2.3.5** Geotextile shall meet [Sec 1011](#) for Type 1 (Subsurface Drainage) geotextile and have an apparent opening size (AOS) corresponding to a U. S. sieve number greater than 50 (300  $\mu\text{m}$ ) but not exceeding 100 (150  $\mu\text{m}$ ).

**1012.3 Certification and Acceptance.**

**1012.3.1** The contractor shall furnish a manufacturer's certification to the engineer, for each lot of material furnished stating the name of the manufacturer and certifying that the material supplied conform to all requirements specified. The certification shall include or have attached typical results of tests from specific lots for all specified requirements, including the geotextile.

**1012.3.2** Acceptance of the material will be based on the manufacturer's certification and upon the results of such tests as may be performed by the engineer.

## SECTION 1013

### MISCELLANEOUS DRAINAGE MATERIAL

**1013.1 Scope.** This specification covers material requirements for various plastic pipes, tubing and other miscellaneous items required to provide underdrainage as specified elsewhere.

#### **1013.2 Material.**

##### **1013.2.1 Plastic Pipe.**

**1013.2.1.1** Corrugated PVC sewer pipe with a smooth interior and fittings shall conform to ASTM F 949.

**1013.2.1.2** Smooth wall PVC underdrain pipe and fittings shall conform to AASHTO M 278.

**1013.2.1.3** Corrugated PE drainage tubing and fittings shall conform to AASHTO M 252.

**1013.2.1.4** Corrugated PE pipe with a smooth interior and fittings shall conform to ASTM F 892, except any perforations shall be provided in accordance with AASHTO M 252.

**1013.2.1.5** Schedule 40 PVC pipe shall conform to ASTM D 1785.

**1013.2.1.6 Certification and Acceptance.** The contractor shall furnish a manufacturer's certification to the engineer, for each lot of plastic pipe material furnished stating the name of the manufacturer and certifying that the material supplied conform to all requirements specified. Acceptance of the material will be based on the manufacturer's certification and upon the results of such tests as may be performed by the engineer.

**1013.2.2 Rodent Screens.** Rodent screen shall be press formed of 3 or 4 mesh, 21 gauge (0.7 mm) or heavier, stainless steel or hot-dipped galvanized wire screen so as to provide a cup-shaped screen which will provide a friction tight fit when inserted into the drain outlet.

**1013.2.2.1 Acceptance.** Acceptance of the material will be based on visual examination and results of such tests as might be performed by the engineer.

## SECTION 1015

### BITUMINOUS MATERIAL

#### 1015.1 General.

**1015.1.1 Approval of Source.** The contractor shall obtain approval of the source of bituminous material from the engineer before any shipments to the work are made.

**1015.1.2 Sampling, Testing and Acceptance Procedures.** The supplier shall guarantee by certification that bituminous material complies with the specification requirements.

**1015.1.2.1** The supplier shall furnish the truck driver a copy of the bill of lading, manifest or truck ticket that is to be available to the engineer at destination prior to unloading. The engineer at the source is also to be furnished a copy. The bill of lading, manifest or truck ticket shall show the following information regarding the shipment: type and grade of material, specific gravity at 60 F (15.6 C), net gallons (liters), consignee, truck number, identification number, weight (mass) of truck before and after loading, destination, date loaded, name and location of the source, and a certification statement. The certification statement shall be signed by an authorized representative of the supplier and shall be substantially as follows:

"This certifies that the bituminous material in this shipment complies with MoDOT specifications for the grade specified and the weights (masses) shown hereon were obtained on MoDOT approved scales and are correct within the specified scale requirements."

**1015.1.2.2** The engineer will at random observe the sampling and testing of truck shipments and tanks, and will select representative samples of the material being supplied. These samples will be tested by the engineer in the field or in the Central Laboratory. When test results certified by the supplier are not representative of the material being shipped, the source approval will be withdrawn. A source may be reinstated when proof is furnished that the deficiency has been corrected and adequate controls are in effect to guarantee delivery of material meeting specifications.

**1015.1.2.3** The supplier shall furnish the required sampling equipment and shall sample the truck under the direction of the engineer. The supplier shall be responsible for keeping all sampling equipment clean and in good condition. Sampling devices on truck transports will be approved provided an adequately insulated valve is used with a pipe or nipple inserted a suitable distance into the tank.

**1015.1.2.4** Each truck transport shall carry a log showing the types of material and dates hauled, with respect to recent shipments or the supplier shall furnish the engineer such information with respect to the previous load.

**1015.1.2.5** Intermediate storage tanks for storage and transfer of material between the refinery or terminal and the point of acceptance shall be equipped for sealing and shall be reserved exclusively for State work. Use of any material from unsealed tanks will be subject to delay until the material can be sampled, tested and approved.

**1015.1.2.6** At sources from which liquid bituminous material is being accepted by certification, the applicable requirements of the foregoing sections shall be followed for

shipments of material in transportation units other than trucks. The certification and all information regarding each shipment shall be furnished to the engineer at the source.

**1015.1.2.7** For railroad shipments from refineries where inspection is not being maintained by the engineer, the supplier shall sample each car load at the source and submit the sample promptly to the Central Laboratory. A bill of lading or identification sheet shall accompany each sample and contain the following information: car number, type and grade of material, quantity represented including gross gallons (liters), temperature and net gallons (liters) at 60 F (15.6 C), destination of shipment, project number and consignee. A certification statement as specified in [Sec 1015.1](#) shall accompany each sample. Approval of the source will be withdrawn when samples submitted are not representative of the material shipped in the car.

**1015.1.3 Proportioning and Blending Bituminous Material Constituents.** All material shall be properly proportioned and thoroughly blended in suitable tanks prior to delivery to transportation equipment or may be proportioned and blended by use of automatic proportioning equipment. All automatic proportioning blenders shall meet the approval of the engineer and shall be equipped with precision instruments, including electrically interlocked motors and automatic meters. Blending in tanks in quantities of less than 8000 gallons (30,000 L) or in tank trucks will not be permitted.

**1015.2 Performance Graded Asphalt Binder.** The grade shall be as specified in the contract.

**1015.2.1** Performance graded asphalt binder shall be an asphalt-based binder produced from petroleum residue either with or without the addition of non-particulate organic modifiers.

**1015.2.2** Performance graded asphalt binder shall be tested in accordance and comply with the requirements of AASHTO MP1 for the grade specified. The physical hardening and direct tension tests are waived.

**1015.2.3** Performance graded asphalt binder shall be furnished as a uniform mixture shipped directly to the project site from the asphalt binder supplier's permanent plant address or intermediate storage facility, suitable for direct use. Asphalt binder shall be capable of storage at the project site without separation or settling. Automatic blending will be allowed, however no intermediate blending of asphalt binder and any other modifiers will be allowed at the project site.

**1015.2.4 Certification and Acceptance.** Suppliers furnishing performance graded asphalt binders to MoDOT projects by certification shall comply with all requirements of AASHTO PP26, except as noted herein. To become pre-qualified to furnish material, a written request shall be sent to the Division Engineer, Materials, along with a copy of the supplier's QC plan. Split samples may be required. In order to maintain qualification, the supplier shall submit satisfactory results of all quality control testing monthly to MoDOT. Changes in formulation, base stock or methods of manufacture of qualified performance graded binders shall be noted and may require re-qualification.

**1015.2.4.1 Quality Control Plan Requirements.** The QC plan shall comply with AASHTO PP26 with the following exceptions and modifications:

(a) It may be written to cover multiple terminals or shipping facilities, in addition to the primary manufacturing facility, provided specific requirements for each location are clearly stated.



(b) It shall state the lot size used to designate the frequency of QC and specification compliance testing for each performance grade to be supplied. The lot size will depend upon the method of manufacture and may be designated on a tank basis, or on a time basis in the case of binders that are blended into trucks or tanks or that are continually blended into "live" tanks.

(c) For terminals or manufacturing facilities, the minimum reduced frequency of testing for QC or specification compliance shall be one series of tests every two weeks for "live" tanks or blenders and one series of tests every four weeks for "static" tanks that have had no material added between testing, per lot per grade of binder shipped.

(d) QC testing may be used to determine that binders being shipped from terminals or manufacturing facilities have not been contaminated, provided that such testing is shown to be of sufficient accuracy to detect contamination and to assure that material meets required specifications. Surrogate tests may be used for QC testing of non-modified performance graded binders.

(e) Terminals or shipping facilities that blend performance graded binders from different sources, that blend to produce a different performance grade, or that blend to modify the properties of an existing performance grade shall perform complete AASHTO MP1 specification compliance testing.

(f) The shipping facility shall document that each transport vessel was inspected prior to loading and was found to be acceptable for the material being shipped. The inspection shall be documented by a statement on the bill of lading or truck ticket or by maintaining a record of transport vessel inspections at the shipping facility, which shall be available for review by MoDOT.

**1015.2.4.2 Quality Control Plan Monthly Report.** A report of QC activity shall be forwarded monthly to MoDOT. This report shall contain, as a minimum, the name of the facility covered by the report, the dates covered by the report, results of individual specification compliance and QC tests identified by blender or tank number, and the mean, minimum and maximum test result for each specification compliance and QC test performed during the period covered by the report. Data shall be furnished in the report for each performance grade shipped during the period covered by the report. The report shall be forwarded to MoDOT no later than two weeks following the end of the period covered by the report. Each set of test results shall be labeled with the exact test description as given in AASHTO MP1.

**1015.2.4.3 Approval of Laboratories.** The supplier's primary testing laboratory shall be approved by MoDOT. The approval process will include split sample testing and may include an on-site visit by department personnel. The primary testing laboratory shall be regularly inspected by the AASHTO Materials Reference Laboratory (AMRL). Any satellite testing laboratory operated by a supplier shall be inspected at the same frequency by the supplier's primary AMRL inspected laboratory staff, and a copy of the inspection report shall be forwarded to MoDOT.

**1015.2.4.4 Failure to Comply.** Failure to fulfill any of these requirements may result in disqualification of the performance graded binder supplier. If a primary manufacturing facility is disqualified, all terminals shipping performance graded binder that is manufactured at the primary facility and who are not performing AASHTO MP1 specification compliance testing will automatically be disqualified also. In cases of dispute, test results obtained by MoDOT will be considered referee and final.

**1015.3 Liquid Bituminous Materials.** Suppliers furnishing liquid bituminous materials shall comply with the following. All truck shipments shall be loaded from approved storage tanks, which have been sampled, tested and certified by the supplier to the engineer. If automatic blending equipment is used, blender material will be approved for use provided the finished product complies with specifications. At least one complete test shall be conducted every 2 weeks on each grade of material furnished for MoDOT work from the blender. A certified copy of the test results shall be furnished to the engineer. Sampling and testing for certification purposes shall be conducted prior to shipping material to MoDOT work. After loading, the supplier shall sample and make identifying tests on a sufficient number of truck shipments of material consigned to a construction project to ensure that proper quality control is being maintained and that all such shipments comply with the specification requirements. The identifying test is viscosity for liquid bituminous material.

**1015.3.1 Type RC Liquid Asphalt.** This material shall be produced by fluxing an asphaltic base with suitable petroleum distillates. The material shall show no separation or curdling prior to use and shall not foam when heated to the application temperature. The material shall conform to the requirements of Table I for the grade specified in the contract.

<b>TABLE I - Type RC Liquid Asphalt</b>								
<b>Tests</b>	<b>RC-70</b>		<b>RC-250</b>		<b>RC-800</b>		<b>RC-3000</b>	
	<b>Min</b>	<b>Max</b>	<b>Min</b>	<b>Max</b>	<b>Min</b>	<b>Max</b>	<b>Min</b>	<b>Max</b>
Water, percent	----	0.2	----	0.2	----	0.2	----	0.2
Flash point (Tag open cup), degrees C	----	----	27	----	27	----	27	----
Viscosity, 60 C, centistokes	70	140	250	500	800	1600	3000	6000
Distillation test:								
Distillate, percentage by volume of total distillate to 360 C:								
to 190 C	10	----	----	----	----	----	----	----
to 225 C	50	----	35	----	15	----	----	----
to 260 C	70	----	60	----	45	----	25	----
to 315 C	85	----	80	----	75	----	70	----
Residue from distillation to 360 C, volume percentage of sample by difference	55	----	65	----	75	----	80	----
Tests on residue from distillation:								
Penetration, 25 C								
100 g, 5 sec	80	120	80	120	80	120	80	120
Ductility, 25 C								
5 cm/min, cm	100	----	100	----	100	----	100	----
Solubility in trichloroethylene, percent	99.0	----	99.0	----	99.0	----	99.0	----

**1015.3.2 Type MC Liquid Asphalt.** This material shall be produced by fluxing an asphaltic base with suitable petroleum distillates. The material shall show no separation or curdling prior to use and shall not foam when heated to the application temperature. The material shall conform to the requirements of Table II for the grade specified in the contract.

TABLE II - Type MC Liquid Asphalt										
Tests	Grade									
	MC-30		MC-70		MC-250		MC-800		MC-3000	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Water, percent	----	0.2	----	0.2	----	0.2	----	0.2	----	0.2
Flash point (Tag open cup), degrees C	38	----	38	----	66	----	66	----	66	----
Viscosity, 60 C, centistokes	30	60	70	140	250	500	800	1600	3000	6000
Distillation test: Distillate, percentage by volume of total distillate to 360 C:										
to 225 C	----	25	----	20	----	10	----	----	----	----
to 260 C	40	70	20	60	15	55	----	35	----	15
to 315 C	75	93	65	90	60	87	45	80	15	75
Residue from distillation to 360 C, volume percentage of sample by difference	50	----	55	----	67	----	75	----	80	----
Tests on residue from distillation:										
Penetration, 25 C										
100 g, 5 sec	120	250	120	250	120	250	120	250	120	250
Ductility, 5 cm/min, cm (1)	100	----	100	----	100	----	100	----	100	----
Solubility in trichloroethylene, percent	99.0	----	99.0	----	99.0	----	99.0	----	99.0	----

- (1) If the ductility at 25 C is less than 100 cm, the material will be acceptable if its ductility at 15.6 C is more than 100 cm.

**1015.3.3 Emulsified Asphalt.** This material shall meet the requirements of AASHTO M 140 or M 208, for the type and grade specified in the contract.

**1015.3.3.1** Bituminous material for polymer modified asphalt emulsion shall comply with the requirements of Table III.

TABLE III - POLYMER MODIFIED ASPHALT EMULSION				
Tests	CRS-2P		EA-90P	
	Min	Max	Min	Max
Viscosity, SSF @ 50 C	100	400	100	400
Storage Stability Test (2), 24 hour, percent	----	1	----	1
Classification Test	Pass	----	----	----
Particle Charge Test	Positive	----	----	----
Sieve Test, 850 $\mu$ m mesh, percent	----	0.3	----	0.3
Demulsibility, 0.02 N CzCl <sub>2</sub> , percent	----	----	30	----
Distillation:				
Oil distillate by volume of emulsion, percent	----	3	----	3
Residue from distillation (3), percent	65	----	65	----
Tests on Residue from Distillation:				
Penetration, 25 C, 100 g, 5 sec	100	200	100	200
Ductility, 4 C, 5 cm/minute, cm	30	----	25	----
Ash (4), percent	----	1	----	1
Float Test at 60 C, sec	----	----	1200	----
Elastic Recovery (5), percent	58	----	58	----

- (1) All tests are performed in accordance with AASHTO T 59 except as noted.
- (2) In addition to AASHTO T 59, upon examination of the test cylinder and after standing undisturbed for 24 hours, the surface shall show no appreciable white, milky colored substance and shall be a homogeneous brown color throughout.
- (3) AASHTO T 59 modified to maintain a  $204 \pm 5$  C maximum temperature for 15 minutes.
- (4) AASHTO T 111, Ash in Bituminous Material.
- (5) Condition the ductilometer and samples to be treated at 10 C. Prepare the brass plate, mold and briquet specimen in accordance with AASHTO T 51. Keep the specimen at the specified test temperature of 10 C for 85 - 95 minutes. Immediately after conditioning, place the specimen in the ductilometer and proceed to elongate the sample to 20 cm at a rate of pull of 5 cm/min. After the 20 cm elongation has been reached, stop the ductilometer and hold the sample in its elongated position for 5 minutes. After 5 minutes, clip the sample approximately in half by means of scissors or other suitable cutting devices. Let the sample remain in the ductilometer in an undisturbed condition for one hour. At the end of this time period, retract the half sample specimen until the two broken ends touch. At this point note the elongation (x) in cm. Calculate the percent recovery by the following formula:

$$\% \text{ Recovery} = \frac{20 - X}{20} \times 100$$

#### 1015.4 Sampling and Test Methods for Asphalt.

Property	Method	RC	MC	PG
Sampling	AASHTO T 40	X	X	X
Water	AASHTO T 55	X	X	X
Flash Point (Tag Open Cup)	AASHTO T 79	X	X	
Flash Point (Cleveland Open Cup)	AASHTO T 48			X
Viscosity, Centistokes	AASHTO T 201	X	X	
Distillation	AASHTO T 78	X	X	
Penetration	AASHTO T 49	X	X	
Ductility	AASHTO T 51	X	X	
Solubility in Trichlorethylene	AASHTO T 44	X	X	X
Viscosity (Rotational)	ASTM D 4402			X
Dynamic Shear	AASHTO TP 5			X
Rolling Thin Film Oven Test	AASHTO T 240			X
Pressure Aging Test	AASHTO PP 1			X
Creep Stiffness	AASHTO TP 1			X
Direct Tension	AASHTO TP 3			X

#### 1015.5 Application Temperatures for Bituminous Materials.

Bituminous Material	Temperature, Degrees Fahrenheit (Celsius)			
	Spraying		Mixing	
	Min	Max	Min	Max
Asphalt Binder PG 46-28	260 (125)	325 (165)	----	----
All Other Grades	285 (140)	350 (175)	275 (135)	350 (175)
Liquid Asphalt RC-MC Grade				
30	70 (20)	150 (65)	50 (10)	110 (45)
70	100 (40)	180 (80)	90 (30)	140 (60)
250	150 (65)	220 (105)	130 (55)	170 (75)
800	180 (80)	260 (125)	170 (75)	210 (100)
3000	210 (100)	290 (145)	200 (95)	240 (115)
Asphalt Emulsions				
RS-1	75 (25)	130 (55)	----	----
RS-2	110 (45)	175 (80)	----	----
SS-1	75 (25)	130 (55)	75 (25)	130 (55)
SS-1h	75 (25)	130 (55)	75 (25)	130 (55)
CRS-1	75 (25)	130 (55)	----	----
CRS-2	110 (45)	175 (80)	----	----
CSS-1	75 (25)	130 (55)	75 (25)	130 (55)
CSS-1h	75 (25)	130 (55)	75 (25)	130 (55)

Application temperatures of other grades of emulsions will be as specified in the contract.

The spraying temperature for non-modified PG 46-28 asphalt binder is 260 - 325 F (125 - 165 C) and for all other higher temperature non-modified performance grades is 285 - 350 F (140 - 175 C). The mixing and compaction temperatures for performance graded asphalt binder shall be determined by rotational viscosity testing as defined in AASHTO TP4.

When material to be applied by pressure distributor is, due to refining or blending procedures, delivered at a temperature above the specified limits, the material may be applied at the higher

temperature provided satisfactory application can be obtained at the specified rate and provided sufficient precaution is exercised with respect to the fire hazard.

**1015.6 Measurement of Bituminous Material.** Field weight (mass) or field volumetric determinations of the material actually incorporated into the work will be used for measurement of the quantity of bituminous material for payment. The volume of material supplied from intermediate storage tanks will be determined from the net weight (mass) of the material. The net weight (mass) will be determined from the gross weight (mass) of the loaded transport vehicle used to deliver the material to the project less the empty transport vehicle weight (mass). The volume correction methods specified below will be used for determining the volume of bituminous material. Scales for determining the weight (mass) of bituminous material shall comply with the requirements of [Sec 310](#).

**1015.6.1 Liquid Bituminous Material and Asphalt Binder - Volumetric Determination.** Measurement of the material will be based on the volume at 60 F (15.6 C). The volume correction factors of ASTM D 1250, Table 24b, will be used for converting the material from the volume at the observed temperature to the volume at 60 F (15.6 C). The volume of uncalibrated distributors and tank trucks will be determined from the net weight (mass) of the material. The net weight (mass) will be determined from the gross weight (mass) of the loaded delivery vehicle less the empty delivery vehicle weight (mass). For computing the volume in gallons (liters) from weight (mass), the following formula will be used:

ENGLISH

$$G = \frac{W}{SG \times 8.328}$$

where:

G = Volume in gallons at 60 F.  
W = Weight of material in pounds.  
SG = Specific Gravity of material at 60 F.

METRIC

$$L = \frac{M}{SG \times 997.914}$$

where:

L = Volume in liters at 15.6 C.  
M = Mass of material in kilograms  
SG = Specific Gravity of material at 15.6 C.

**1015.6.2 Emulsified Asphalt.** Measurement of the material will be based on the volume at 60 F (15.6 C) using a coefficient of expansion of 0.0003 per degree F (0.00054 per degree C) for converting the material from the volume at the observed temperature to the volume at 60 F (15.6 C).

## SECTION 1017

### GROUND GRANULATED BLAST FURNACE SLAG

**1017.1 Scope.** These specifications cover ground granulated blast furnace slag (GGBFS) intended for use in concrete.

**1017.2 General.** All GGBFS shall conform to the requirements of AASHTO M 302, Grade 120, except as herein specified. Only GGBFS from sources qualified in accordance with these specifications will be permitted.

**1017.2.1** GGBFS may only be used with AASHTO M 85 Type I or Type II portland cement unless otherwise directed by the engineer.

**1017.2.2** The mixing of different grades and sources of GGBFS will not be permitted.

**1017.2.3** The term "manufacturer", as used in this specification, is the company grinding the granulated blast furnace slag to produce GGBFS. The term "marketing entity", as used in this specification, is the supplier or broker of the GGBFS. The marketing entity shall be responsible for complying with these specifications.

**1017.2.4** All tests shall be performed in a MoDOT approved laboratory.

**1017.3 Sampling, Testing and Acceptance Procedures.** All marketing entities and terminals furnishing GGBFS to MoDOT projects shall be qualified as herein described. All GGBFS shall be subject to inspection and sampling by MoDOT at the source of manufacture, an intermediate shipping terminal or destination. MoDOT shall be allowed free access to all facilities and records as required to conduct inspection and sampling.

**1017.3.1 Marketing Entity Qualification.** In order to become qualified, a written request shall be sent by the marketing entity to the Division Engineer, Materials, along with a copy of their QC plan and the following information. In order to maintain qualification, the marketing entity shall submit additional information, as listed, to MoDOT. The production source and terminals may be inspected to verify the information and to establish personal contact with the QC personnel.

**1017.3.1.1** The following information shall be included in the request for qualification.

(a) An outline of the QC program from the source of manufacture to the point where the product is relinquished to the purchaser. The QC program shall cover all tests required by the specification and include the testing frequency for each test. The name of the testing laboratory shall be included. Each sample shall not represent less than 500 tons (500 Mg).

(b) A copy of the testing laboratory's most recent Cement and Concrete Reference Laboratory (CCRL) inspection report and the latest CCRL proficiency sample report. The CCRL inspection shall cover all tests required by the specification. Documentation showing satisfactory resolution of all inspection deficiencies shall be included.

(c) Complete name and address of the GGBFS source and owner. If located in an area without precise address identification, a complete map description shall be furnished. If more than one source is used, all sources shall be listed.

(d) Grade of GGBFS produced.

(e) Description of storage facilities, including capacities, set-aside capabilities and sampling method(s).

(f) A copy of a typical bill of lading with the required certification statement.

(g) A split sample of the GGBFS proposed for use, obtained over a minimum of one production day. The marketing entity's test results for the split sample shall also be submitted. The marketing entity shall provide reference cement if the cement used is unavailable to the area.

**1017.3.1.2** In order to maintain qualification, the following is required.

(a) Monthly QC test results covering the production of all GGBFS proposed for use in MoDOT projects, including the high, low and average results shall be forwarded to MoDOT, no later than two weeks following the end of the period covered by the report. The report shall consist of, but is not limited to, results from the following tests.

(b) A sample shall be tested for each 2000 tons (2000 Mg) intended for use. The sample shall be tested by the marketing entity for fineness, No. 325 (45  $\mu$ m) sieve analysis and Blaine, air content, 7 day and 28 day Slag Activity Index, percent Sulfide Sulfur (S) and percent Sulfate Ion ( $\text{SO}_3$ ), taken from a composite sample representing each 2000 tons (2000 Mg) of GGBFS transported to the storage silo. The composite shall be comprised of a minimum of four samples, each representing not more than 500 tons (500 Mg). Automatic samplers may be used in lieu of the individual 500 ton (500 Mg) grab samples.

(c) A copy of the most recent CCRL inspection and proficiency sample reports and any deficiency resolutions shall be forwarded promptly to MoDOT.

(d) Quarterly split samples for the class of approved GGBFS will be obtained by MoDOT for joint testing by the marketing entity. Marketing entity test results on the split samples shall be furnished to MoDOT when completed.

(e) All QC test results shall be available for a minimum of three years, for MoDOT review upon request.

(f) No GGBFS out of specification shall be allowed into a silo destined for MoDOT projects.

**1017.3.2 Terminal Qualification.** In order to become a qualified terminal, a written request shall be sent from terminal personnel to the Division Engineer, Materials. The request shall be accompanied by a letter from each affected and qualified marketing entity, advising of the intent to ship through the respective terminal. Any changes in GGBFS source shall be updated in the same manner. Terminals will be inspected to ensure adequacy to accept, retain and ship GGBFS from qualified marketing entities.

**1017.3.3 Failure to Comply.** Failure to fulfill any of these requirements may result in disqualification of the GGBFS manufacturer, marketing entity or a terminal. If a manufacturer is disqualified, all terminal shipped GGBFS originating from that manufacturer will automatically and immediately be disqualified also. If a marketing entity is disqualified, all GGBFS handled or brokered by that entity may be disqualified until the issue is resolved, regardless of the manufacturer. If a terminal is disqualified, all GGBFS shipped from that



terminal may be disqualified until the issue is resolved, regardless of the manufacturer. In cases of dispute, test results obtained by MoDOT will be considered referee and final.

**1017.3.4 Disqualified Facilities.** If a facility has been disqualified, the marketing entity will be required to designate the silo, bin or storage facility from which they propose to furnish GGBFS for MoDOT projects. Each silo, bin or storage facility designated must be sampled, tested, sealed and approved by MoDOT prior to shipment. The marketing entity shall also sample, test and report the test results for each designated silo, bin or storage facility. This procedure will continue until adequate QC has been established.

**1017.3.5** GGBFS continually sampled and tested via autosamplers at a location, frequency and duration acceptable to MoDOT, may be continuously shipped direct from a marketing entity. All GGBFS manually sampled and tested shall be held in the silo or bin until such time as the test results are completed prior to shipping.

**1017.3.6** All GGBFS intended for use shall be sampled, tested and placed in a designated silo or bin.

**1017.4 Acceptance.** It shall be the responsibility of the marketing entity to guarantee by certification the material complies with the specification requirements. When a qualified marketing entity or terminal is shipping GGBFS for, or purchasing GGBFS from, another qualified marketing entity, the bill of lading or delivery receipt shall be from the shipping company. The certification statement showing the actual manufacturer shall be prominently placed on the bill of lading or delivery receipt. A copy of the bill of lading or delivery receipt shall accompany each shipment and shall be furnished to MoDOT at the shipping and destination points.

**1017.4.1** The bill of lading or delivery receipt for each shipment to MoDOT projects shall carry the following certification statement:

"This is to certify this GGBFS originated from a MoDOT qualified manufacturer, has been maintained to meet MoDOT specifications and was loaded from silo number \_\_\_\_\_."

\_\_\_\_\_  
Name and Location of Manufacturer

\_\_\_\_\_  
Name and Location of Shipping Facility

By \_\_\_\_\_  
Signature and Name of Marketing Entity

## SECTION 1018

### FLY ASH FOR CONCRETE

**1018.1 Scope.** These specifications cover fly ash intended for use in concrete.

**1018.2 General.** Only fly ash from sources qualified in accordance with these specifications will be permitted. The mixing of different classes and sources of fly ash will not be permitted. All fly ash shall conform to the requirements of AASHTO M 295, Class C or F, except as herein specified.

**1018.2.1** The available alkalis, as  $\text{Na}_2\text{O}$ , shall not exceed 1.5 percent.

**1018.2.2** The percent each of Silicon Dioxide ( $\text{SiO}_2$ ), Aluminum Oxide ( $\text{Al}_2\text{O}_3$ ) and Iron Oxide ( $\text{Fe}_2\text{O}_3$ ) shall be reported in addition to the total of the three.

**1018.2.3** The term "manufacturer", as used in this specification, is the actual manufacturer of the fly ash. The term, "marketing entity", as used in this specification, is the supplier or broker of the fly ash. The marketing entity shall be responsible for complying with these specifications.

**1018.2.4** Cement used by the marketing entity for testing fly ash shall meet the requirements of AASHTO M 85.

**1018.2.5** All tests shall be performed in a MoDOT approved laboratory.

**1018.3 Sampling, Testing and Acceptance Procedures.** All marketing entities and terminals furnishing fly ash to MoDOT projects shall be qualified as herein described. All fly ash shall be subject to inspection and sampling by MoDOT at the power plant, an intermediate shipping terminal or destination. MoDOT shall be allowed free access to all facilities and records as required to conduct inspection and sampling.

**1018.3.1 Marketing Entity Qualification.** In order to become qualified, a written request shall be sent by the marketing entity to the Division Engineer, Materials, along with a copy of their QC plan and the following information. In order to maintain qualification, the marketing entity shall submit additional information, as listed, to MoDOT. The power plant and terminals may be inspected to verify the information and to establish personal contact with the QC personnel.

**1018.3.1.1** The following information shall be included in the request for qualification.

(a) An outline of the QC program from the coal yard to the point where the product is relinquished to the purchaser. The QC program shall cover all tests required by the specification and include the testing frequency for each test. The name of the testing laboratory shall be included.

(b) A copy of the testing laboratory's most recent Cement and Concrete Reference Laboratory (CCRL) inspection report and the latest CCRL proficiency sample report. The CCRL inspection shall cover all tests required by the specification. Documentation showing satisfactory resolution of all inspection deficiencies shall be included.

(c) Complete name and address of the fly ash source and owner. If located in an area without precise address identification, a complete map description shall be furnished.

(d) Complete name and address or map location of the coal mine. If more than one source of coal is used, all sources shall be listed.

(e) Type of coal used.

(f) Class of fly ash produced.

(g) A description of production procedures including, but not limited to, any additives mixed with the coal during production, any additive or dust suppressant used to collect the fly ash, ash collection methods, production capacity in tons (megagrams) per day and the proportions and proportioning procedures of any blended coals.

(h) Description of storage facilities, including capacities and set-aside capabilities.

(i) A copy of a typical bill of lading with the required certification statement.

(j) A split sample of the class of fly ash proposed for use, obtained from the autosampler over a minimum of one production day. If the fly ash is manually sampled, the split sample shall consist of a composite of 100 gram samples taken where directed by MoDOT, every hour over a minimum of one production day. The marketing entity's test results for the split sample shall also be submitted.

**1018.3.1.2** In order to maintain qualification, the following is required.

(a) Monthly QC test results covering the production of all fly ash proposed for use in MoDOT projects, including the high, low and average results for each class shall be forwarded to MoDOT, no later than two weeks following the end of the period covered by the report, with the exception of the alkali test results which shall be submitted quarterly. The report shall consist of, but is not limited to, results from the following tests.

(b) A sample shall be tested for each 400 tons (400 Mg) intended for use. The sample shall be tested by the marketing entity for fineness, No. 325 (425  $\mu$ m) sieve analysis, moisture content, specific gravity and loss of ignition.

(c) The marketing entity shall perform complete chemical and physical tests on a composite of the samples representing each silo or for each 3000 tons (3000 Mg) intended for use.

(d) A copy of the most recent CCRL inspection and proficiency sample reports and any deficiency resolutions shall be forwarded promptly to MoDOT.

(e) Quarterly split samples for the class of approved fly ash will be obtained by MoDOT for joint testing by the marketing entity. Marketing entity test results on the split samples shall be furnished to MoDOT when completed.

(f) All QC test results shall be available for a minimum of three years, for MoDOT review upon request.

(g) No fly ash out of specification shall be allowed into a silo destined for MoDOT projects.

**1018.3.2 Terminal Qualification.** In order to become a qualified terminal, a written request shall be sent from terminal personnel to the Division Engineer, Materials. The request shall be accompanied by a letter from each affected and qualified marketing entity, advising of the intent to ship through the respective terminal. Any changes in fly ash source shall be updated in the same manner. Terminals will be inspected to ensure adequacy to accept, retain and ship fly ash from qualified marketing entities.

**1018.3.3 Failure to Comply.** Failure to fulfill any of these requirements may result in disqualification of the fly ash manufacturer, marketing entity or a terminal. If a manufacturer is disqualified, all terminal shipped fly ash originating from that manufacturer will automatically and immediately be disqualified also. If a marketing entity is disqualified, all fly ash handled or brokered by that entity may be disqualified until the issue is resolved, regardless of the manufacturer. If a terminal is disqualified, all fly ash shipped from that terminal may be disqualified until the issue is resolved, regardless of the manufacturer. In cases of dispute, test results obtained by MoDOT will be considered referee and final.

**1018.3.4 Disqualified Facilities.** If a facility has been disqualified, the marketing entity will be required to designate the silo, bin or storage facility from which they propose to furnish fly ash for MoDOT projects. Each silo, bin or storage facility designated must be sampled, tested, sealed and approved by MoDOT prior to shipment. The marketing entity shall also sample, test and report the test results for each designated silo, bin or storage facility. This procedure will continue until adequate QC has been established.

**1018.3.5** Fly ash continually sampled and tested via autosamplers at a location, frequency and duration acceptable to MoDOT, may be continuously shipped direct from a marketing entity or generating station silo. Fly ash manually sampled and tested shall be held in the silo or bin until such time as the test results are completed prior to shipping.

**1018.3.6** Fly ash from each coal source at each plant shall be qualified separately. Coals from different sources may be blended prior to burning, but the qualification must be based on the blend.

**1018.3.7** When the production procedure or fuel source is changed, or when any change is made by the manufacturer that alters the properties or characteristics of the qualified fly ash, requalification may be required.

**1018.3.8** All fly ash intended for use shall be sampled, tested and placed in a designated silo or bin. The designated silo or bin shall have a capacity of no less than 1000 tons (1000 Mg) or two days production, whichever is larger.

**1018.4 Acceptance.** It shall be the responsibility of the marketing entity to guarantee by certification the material complies with the specification requirements. When a qualified marketing entity or terminal is shipping fly ash for, or purchasing fly ash from, another qualified marketing entity, the bill of lading or delivery receipt shall be from the shipping company. The certification statement showing the actual manufacturer shall be prominently placed on the bill of lading or delivery receipt. A copy of the bill of lading or delivery receipt shall accompany each shipment and shall be furnished to MoDOT at the shipping and destination points.

**1018.4.1** The bill of lading or delivery receipt for each shipment to MoDOT projects shall carry the following certification statement:

"This is to certify this Class \_\_\_\_ fly ash originated from a MoDOT qualified manufacturer, has been maintained to meet MoDOT specifications and was loaded from silo number \_\_\_\_."

\_\_\_\_\_  
Name and Location of Manufacturer

\_\_\_\_\_  
Name and Location of Shipping Facility

By \_\_\_\_\_  
Signature and Name of Marketing Entity

## SECTION 1019

### CEMENT

**1019.1 Scope.** These specifications cover portland cement, Type IP portland-pozzolan cement, Type I(PM) pozzolan modified portland cement, Type IS portland blast-furnace slag cement and Type I(SM) slag-modified portland cement.

**1019.2 General.** All portland cement shall conform to the requirements of AASHTO M 85.

**1019.2.1** All blended hydraulic cement shall conform to the requirements for Type IP, I(PM), IS or I(SM) of AASHTO M 240 with the following modifications.

(a) Type IP or I(PM) cement shall be produced by intergrinding portland-cement clinker and pozzolan. Blending methods of production shall not be used.

(b) The pozzolan constituent of Type IP shall not exceed 20 percent by weight (mass) of the total portland-pozzolan cement.

(c) Type IS or I(SM) cement shall be produced by intergrinding portland cement clinker and granulated blast-furnace slag. Blending methods of production shall not be used.

(d) The granulated slag constituent of Type IS or I(SM) shall not exceed 25 percent by weight (mass) of the total portland-slag cement.

(e) All slag shall conform to AASHTO M 302 and be ground to the fineness of the cement in which slag is used.

(f) The basis of acceptance shall be as described in [Sec 1019.3](#) in addition to AASHTO M 240.

**1019.2.2** Types I, II, IP, I(PM), IS or I(SM) cement shall be used for all general concrete construction except as herein specified or where other types of cement are permitted. Types IP, I(PM), IS or I(SM) shall not be used in concrete designed for high early strength. Type I or Type III portland cement shall be used in high early strength concrete. Type III portland cement may be used in any precast concrete. White portland cement shall meet the requirements for Type I. Type IA, air-entraining portland cement, shall be used only when specified in the contract. Different types of cement shall not be mixed nor shall different types be used in the same unit of construction.

**1019.2.3** A sack or bag of cement is considered to be 94 pounds (42.6 kg) net.

**1019.3 Sampling, Testing and Acceptance Procedures.** All manufacturers and terminals furnishing cement to MoDOT projects shall be qualified as herein described. All cement shall be subject to inspection and sampling by MoDOT at the source of manufacture, an intermediate shipping terminal or destination. MoDOT shall be allowed free access to all facilities and records as required to conduct inspection and sampling.

**1019.3.1 Manufacturer Qualification.** In order to become qualified, a written request shall be sent by the manufacturer to the Division Engineer, Materials, along with a copy of their QC plan and the following information. In order to maintain qualification, the manufacturer shall

submit additional information, as listed, to MoDOT. The plant may be inspected to verify the information and to establish personal contact with the QC personnel.

**1019.3.1.1** The following information shall be included in the request for qualification.

(a) An outline of the QC program from the quarry to the point where the product is relinquished to the purchaser. The QC program shall cover all tests required by the specification and include the testing frequency for each test.

(b) A copy of the most recent Cement and Concrete Reference Laboratory (CCRL) inspection report and the latest CCRL proficiency sample report. The CCRL inspection shall cover all tests required by the specification. Documentation showing satisfactory resolution of all inspection deficiencies shall be included.

(c) The physical layout of the plant, including the number and capacity of finish mills and silos and the type of cement stored in each silo.

(d) A copy of a typical bill of lading with the required certification statement.

(e) A split sample of each type of cement proposed for use. Manufacturer test results for the split sample shall also be submitted.

**1019.3.1.2** In order to maintain qualification, the following is required.

(a) Monthly QC test results covering the production of cement types proposed for use in MoDOT projects, including the high, low and average results for each type shall be forwarded to MoDOT, no later than two weeks following the end of the period covered by the report.

(b) A copy of the most recent CCRL inspection and proficiency sample reports and any deficiency resolutions shall be forwarded promptly to MoDOT.

(c) Quarterly split samples for each type of approved cement will be obtained by MoDOT for joint testing by the manufacturer. Manufacturer test results on the split samples shall be furnished to MoDOT when completed.

(d) All QC test results shall be available for a minimum of three years, for MoDOT review upon request.

(e) No cement out of specification shall be allowed into a silo destined for MoDOT projects.

**1019.3.2 Terminal Qualification.** In order to become a qualified terminal, a written request shall be sent from terminal personnel to the Division Engineer, Materials. The request shall be accompanied by a letter from each affected and qualified manufacturer, advising of the intent to ship through the respective terminal. Any changes in cement source shall be updated in the same manner. Terminals will be inspected to ensure adequacy to accept, retain and ship cement from qualified manufacturers.

**1019.3.3 Failure to Comply.** Failure to fulfill any of these requirements may result in disqualification of the cement manufacturer or a terminal. If a manufacturer is disqualified, all terminal shipped cement originating from that manufacturer will automatically and immediately be disqualified also. If a terminal is disqualified, all cement shipped from that

terminal may be disqualified until the issue is resolved, regardless of the manufacturer. In cases of dispute, test results obtained by MoDOT will be considered referee and final.

**1019.3.4 Disqualified Manufacturers.** If a manufacturer has been disqualified, they will be required to designate the silo, bin or storage facility from which they propose to furnish cement for MoDOT projects. Each silo, bin or storage facility designated must be sampled, tested, sealed and approved by MoDOT prior to shipment. The manufacturer shall also sample, test and report the test results for each designated silo, bin or storage facility. This procedure will continue until adequate QC has been established.

**1019.3.5 Foreign Cement.** All tests on foreign cement shall be performed by a qualified domestic manufacturer.

**1019.4 Acceptance.** It shall be the responsibility of the supplier to guarantee by certification the material complies with the specification requirements. When a qualified manufacturer or terminal is shipping cement for, or purchasing cement from, another qualified manufacturer, the bill of lading or delivery receipt shall be from the shipping company. The certification statement showing the actual manufacturer shall be prominently placed on the bill of lading or delivery receipt. A copy of the bill of lading or delivery receipt shall accompany each shipment and shall be furnished to MoDOT at the shipping and destination points.

**1019.4.1** The bill of lading or delivery receipt for each shipment to MoDOT projects shall carry the following certification statement:

"This is to certify this Type \_\_\_\_ cement originated from a MoDOT qualified manufacturer, has been maintained to meet MoDOT specifications and was loaded from silo number \_\_\_\_."

\_\_\_\_\_  
Name and Location of Manufacturer

\_\_\_\_\_  
Name and Location of Shipping Facility

By \_\_\_\_\_  
Signature and Name of Marketing Entity



## SECTION 1020

### CORRUGATED METALLIC-COATED STEEL CULVERT PIPE, PIPE-ARCHES AND END SECTIONS

**1020.1 Scope.** These specifications cover corrugated steel pipe, pipe-arches and flared end sections intended to be used for the construction of culverts and similar uses. The steel used in fabrication has a protective metallic coating of zinc (galvanizing) or aluminum.

#### Material

**1020.2 Steel Sheet.** The steel sheet used for fabrication shall be coated on both sides by the hot-dip process with zinc or aluminum in accordance with the requirements herein specified. The coated steel sheet may be furnished flat in coils or cut lengths or corrugated in cut lengths. The steel sheet may be sheared to proper size after coating. Finished steel sheet shall be of first-class commercial quality, free from injurious defects such as blisters, flux and uncoated spots.

**1020.2.1 Chemical Composition.** The base metal composition of the steel sheet shall comply with the requirements of Table I.

**1020.2.2 Mechanical Properties.** The metallic-coated steel when tested in the longitudinal direction of steel sheets prior to corrugation or other fabrication shall comply with the requirements of Table II. Steel sheet tested after corrugating or other fabrication shall conform to the tensile and yield strength requirements of Table II but the elongation will not be required.

**1020.2.3 Thickness.** Sheet thickness shall conform to the dimensions shown in Table III. The thickness of the sheet includes both the steel and the coating.

**1020.2.4 Corrugations.** The dimensions of the corrugations shall be in accordance with Table IV. Corrugations shall form smooth continuous curves and tangents.

**1020.2.5 Width.** Covering width of corrugated cut lengths shall be in accordance with Table V. Covering width is the distance between the crests of the outermost corrugations. There is no established tolerance for overall width since the covering width and lip dimensions are the governing factors for the formed product.

**1020.2.6 Edge Lip.** Lip dimensions of corrugated cut lengths shall be in accordance with Table VI. The lip dimension is measured along the radial curvature from the crest of the outermost corrugation to the edge of the sheet.

**1020.2.7 Zinc Coating.** Zinc for coating (galvanizing) shall be prime western grade or better. Zinc-coated steel shall have a weight (mass) of zinc coating not less than 2.00 ounces per square foot (610 g/m<sup>2</sup>) of double exposed surface. If the average weight of zinc coating as determined from the required samples is less than 2.00 ounces per square foot (610 g/m<sup>2</sup>) or if any one specimen has less than 1.80 ounces of zinc per square foot (550 g/m<sup>2</sup>) of double exposed surface, the lot sampled will be rejected or resampled as determined by the engineer. If a retest is made, the weight (mass) of zinc coating of all the original samples and the samples for retest must average at least 2.00 ounces per square foot (610 g/m<sup>2</sup>) of double exposed surface and no specimen shall have less than 1.80 ounces per square foot (550 g/m<sup>2</sup>)

or the entire lot sampled will be rejected. Adherence of coating shall be such that no peeling occurs while the material is being corrugated or formed into pipe.

**1020.2.8 Aluminum Coating.** Aluminum for coating shall be commercially pure aluminum and the bath analysis shall conform to the requirements of Table VII. Aluminum-coated steel shall have a weight (mass) of aluminum coating not less than 1.00 ounce per square foot ( $305 \text{ g/m}^2$ ) of double exposed surface. If the average weight (mass) of aluminum coating as determined from the required samples is less than 1.00 ounce per square foot ( $305 \text{ g/m}^2$ ) or if any one specimen has less than 0.90 ounce of aluminum per square foot ( $275 \text{ g/m}^2$ ) of double exposed surface, the lot sampled will be rejected or resampled, as determined by the engineer. If a retest is made, the weight (mass) of aluminum coating of all the original samples and the samples for retest must average at least 1.00 ounce per square foot ( $305 \text{ g/m}^2$ ) of double exposed surface and no specimen shall have less than 0.90 ounce per square foot ( $275 \text{ g/m}^2$ ) or the entire lot sampled will be rejected.

**1020.3 Rivets.** The rivets used in riveted fabrication shall be of the same material as the base metal specified for the steel sheet. They shall be thoroughly galvanized or sherardized.

**1020.4 Bolts and Nuts.** Bolts, nuts and other threaded articles used with coupling bands and end sections and other hardware items used with coupling bands, shall be coated by one of the processes specified in AASHTO M 36.

**1020.5 Basis of Acceptance.** Acceptance of metallic-coated steel sheet will be based upon a satisfactory sheet manufacturer's certified analysis and guarantee and sheet identification markings or upon tests on samples of the material or upon both. The frequency of sampling will be determined by the engineer. The fabricator shall provide the equipment and personnel required to obtain the samples as directed by the engineer.

**1020.6 Accepted Brands of Metal.** No metal will be accepted under these specifications until the sheet manufacturer's certified analysis and manufacturer's guarantee have been approved by the engineer. Misbranding or other misrepresentation and non-uniformity of product, will each be considered a sufficient reason to discontinue the acceptance of any brand under these specifications and notice sent to the sheet manufacturer of the discontinuance of acceptance of any brand will be considered to be notice to all culvert companies which handle that particular brand.

**1020.6.1 Sheet Manufacturer's Certified Analysis.** The manufacturer of each brand shall file with the Division Engineer, Materials, a certificate setting forth the name or brand of metal to be furnished, the specified chemical composition and a typical or average analysis showing the percent of carbon, phosphorus, manganese, sulfur and silicon. The certificate shall be sworn to, for the manufacturer, by a person having legal authority to bind the company.

**1020.6.2 Sheet Manufacturer's Guarantee.** The manufacturer of the steel sheet shall submit with the certified analysis a guarantee providing that all metal furnished shall conform to the specification requirements, shall bear a suitable identification brand or mark and shall be replaced without cost to the Commission when not in conformity with the specified analysis, sheet thickness or coating; and the guarantee shall be so worded as to remain in effect so long as the manufacturer continues to furnish material. The manufacturer shall make such tests and measurements as necessary to ensure that the material produced complies with all specification requirements. These tests and measurements shall be identified by the identification symbols or code used on the sheet in a manner which will permit the manufacturer to produce specific reports showing test results representative of specific lots of steel sheet. Copies of reports of these tests shall be kept on file and shall be submitted to the

engineer upon request. The brand shall be removed or obliterated by the manufacturer on all material where control tests, as outlined herein, do not show conformance to this specification.

**1020.7 Sampling.** Samples of coated steel sheet may be obtained from coils, flat or corrugated cut lengths or fabricated culverts. Samples will be taken at a frequency determined by the engineer.

**1020.7.1** For testing weight (mass) of coating of flat or corrugated cut lengths before fabrication, three specimens, each not less than 2 1/4 inches (60 mm) square or of an equivalent area, shall be taken from each test sheet selected to represent the lot. The specimens shall be so taken that no part includes metal closer than 2 inches (50 mm) from an edge or 4 inches (100 mm) from an end of the cut length. These specimens shall be obtained in any one of the following patterns:

(a) One specimen shall be obtained from the center of the cut length and the other two from diagonally opposite corners.

(b) The specimens shall be taken from one end of the cut length, one from the middle portion and one from near each edge.

**1020.7.2** For testing weight (mass) of coating of coils before fabrication, three specimens, each not less than 2 1/4 inches (60 mm) square or of an equivalent area, shall be taken, one from the middle of the width and one from each side. No specimen shall be taken closer than 2 inches (50 mm) from an edge or 4 inches (100 mm) from an end of the coil.

**1020.7.3** For testing weight (mass) of coating of fabricated pipe or pipe-arch, at least one specimen 2 1/4 inches (60 mm) square or of equivalent area, shall be selected for each 20 pieces in a shipment, provided that not less than three specimens each from a different piece, shall represent any one shipment. The three specimens shall constitute one sample and shall meet the requirements of [Sec 1020.2](#).

**1020.7.4** For chemical analysis of the base metal of flat or corrugated cut lengths before the fabrication, a specimen, not less than 2 1/4 inches (60 mm) square or of an equivalent area, shall be taken from each of three different cut lengths for lots weighing 5 tons (for lots having a mass of 5 Mg) or less, from four cut lengths for lots weighing more than 5 and less than 10 tons (for lots having a mass of more than 5 Mg and less than 10 Mg) and from five cut lengths for lots weighing 10 tons (for lots having a mass of 10 Mg) or more. Drillings or chips from the specimens shall be thoroughly mixed for analysis.

**1020.7.5** For chemical analysis of the base metal of coils, three specimens, each not less than 2 1/4 inches (60 mm) square or of an equivalent area, shall be taken from across the width of the coil or if more than one mill lift or coil is involved, three specimens shall be selected from each of at least two different coils. Drillings or chips from the specimens shall be thoroughly mixed for analysis.

**1020.7.6** When chemical analysis of base metal of fabricated pipe or pipe-arch is required, it will be performed on the same specimens taken for determination of weight (mass) of coating.

**1020.7.7** For testing mechanical properties of the base metal, two specimens, each 4 x 14 inches (100 x 355 mm), shall be taken from one end of a cut length or coil. The 14-inch (355 mm) dimension shall be in the longitudinal direction of the steel sheet. No specimen shall be taken closer than 2 inches (50 mm) from an edge or 4 inches (100 mm) from an end of a sheet.

**1020.7.8** Samples for retest of weight (mass) of coating on cut lengths shall be taken in accordance with pattern (a) of [Sec 1020.7.1](#). Samples for retest of mechanical properties or chemical composition of any base metal or retest of weight (mass) of coating on coils or fabricated pipe or pipe-arch shall be taken in the same manner as for the original test.

**1020.8 Testing.** Tests for weight (mass) of coating, chemical composition and mechanical properties of metallic-coated steel sheets shall be as herein specified.

**1020.8.1** Test specimen size and method of test for determining weight (mass) of coating shall be in accordance with AASHTO T 65 for zinc coatings and AASHTO T 213 for aluminum coatings. At the option of the engineer, material may be accepted on the basis of magnetic gauge determinations made in accordance with ASTM E 376.

**1020.8.2** The method of test for chemical analysis shall be in accordance with ASTM E 30-68, exclusive of any later revisions or additions.

**1020.8.3** Test specimen size and method of test for determining tensile strength, yield strength and elongation shall be in accordance with ASTM A 370 for sheet steel.

### **Fabrication**

**1020.9 Shape.** Pipe shall be of full circle or pipe-arch in accordance with Table IX or X or other shape as shown on the plans. Pipe shall be fabricated with circumferential corrugations and with riveted or resistance spot welded lap joint construction or with helical corrugations with a continuous lock or welded seam extending from end to end of each length of pipe. Pipe-arches shall consist of corrugated metal pipe which have been reformed to multi-circle pipe having arch-shaped tops with slightly outwardly centered integral bottoms.

**1020.10 Corrugations.** Corrugations shall form smooth continuous curves and tangents. The corrugations shall be either annular or helical. The direction of the crests and valleys of helical corrugations shall not be less than 60 degrees from the axis of the pipe for pipe diameters larger than 21 inches (525 mm) and not less than 45 degrees from the axis for pipe diameters of 21 inches (525 mm) and smaller.

**1020.11 Dimensions.** The diameters, width of laps, sheet thickness, specified corrugation and dimensions of pipe and pipe-arch shall be as shown in Tables VIII, IX and X.

**1020.11.1** The length of pipe specified shall be the net length of the finished pipe. If the average deficiency in length of any shipment of pipe is greater than one percent, the shipment will be rejected.

**1020.12 Riveted Seams.** Riveted longitudinal seams shall be staggered to the extent that no more than three thicknesses of steel sheet are fastened by any rivet. The longitudinal seams shall be located within 120 degrees of arc for pipe of 36-inch (900 mm) diameter or less and within 240 degrees of arc for pipe larger than 36-inch (900 mm) diameter, so that pipe may be installed without longitudinal seams in the invert. In any case a longitudinal seam will not be allowed on the corner radius of pipe-arch.

**1020.12.1** The size of rivets shall be as shown in Table XI, for the sheet thickness and corrugation size designated. The width of lap shall be as shown in Table VIII. Circumferential seams shall have a maximum rivet spacing of 6 inches (150 mm), measured on centers, except that six rivets will be sufficient in 12-inch (300 mm) diameter pipe. Longitudinal seams of pipe with 1/2 inch (13 mm) deep corrugations shall be riveted with one rivet per corrugation on pipe 36 inches (900 mm) or less in diameter and with two rivets per

corrugation on pipe 42 inches (1050 mm) or more in diameter. All sizes of pipe having one-inch (25 mm) deep corrugations shall have two rivets per corrugation.

**1020.12.2** All rivets shall be driven cold in such a manner that the steel sheet shall be drawn tightly together throughout the entire lap. All rivets shall be placed in the valley of the corrugation. The center of a rivet shall be no closer than twice its diameter from the edge of the sheet. All rivets shall have neat, workmanlike and full hemispherical heads or heads of a form acceptable to the engineer, shall be driven without bending and shall completely fill the hole.

**1020.13 Resistance Spot Welded Seams.** Spot welded longitudinal seams shall be staggered to the extent that no more than three thicknesses of steel sheet are fastened by any spot weld. The longitudinal seams shall be located within 120 degrees of arc for pipe of 36-inch (900 mm) diameter or less or within 240 degrees of arc for pipe larger than 36-inch (900 mm) diameter, so that the pipe may be installed without longitudinal seams in the invert. In any case a longitudinal seam will not be allowed on the corner radius of pipe arch.

**1020.13.1** The size of spot weld shall be as shown in Table XI, for the sheet thickness and corrugation size designated. The width of lap shall be as shown in Table VIII. Circumferential seams shall have a maximum weld spacing of 6 inches (150 mm), except that six welds will be sufficient in 12-inch (300 mm) diameter pipe. Longitudinal seams of pipe with 1/2-inch (13 mm) deep corrugations shall be spot welded with one spot weld per corrugation on pipe 36 inches (900 mm) or less in diameter and with two spot welds per corrugation on pipe 42 inches (1050 mm) or more in diameter. All sizes of pipe having one-inch (25 mm) deep corrugations shall have two spot welds per corrugation. The spot welds may be placed in either the valley, crest or tangent of the corrugation.

**1020.13.2** All spot welds shall be made in such a manner that the steel sheet will be drawn tightly together throughout the lap. The outside edge of each spot weld shall be at least 1/4 inch (6 mm) from the edge of the sheet. The welding shall be performed in such a manner that the exterior surfaces of 90 percent or more of the spot welds on a length of pipe shall show no evidence of melting or burning of the base metal and the base metal shall not be exposed when the area adjacent to the electrode contact surface area is wire brushed. Discoloration of the spot weld surfaces will not be cause for rejection.

**1020.13.3** Welding equipment shall be of sufficient capacity, of such design and in such condition as to make possible the production of first class welds. Before being permitted to perform welding on corrugated metal pipe and coupling bands, resistance spot welding machines and operators shall be qualified by means of the tests hereinafter specified. Qualification tests shall be made in the presence of the engineer and identified by a qualification test number. Three tension shear tests representing each brand and thickness of metal to be used in the manufacture of the pipe shall be performed. Specimens for pipe shall be prepared by lapping two strips of corrugated steel sheet 1 1/2 x 7 inches (40 x 180 mm) and joining them together by a single spot weld duplicating the size to be used in production. Specimens for coupling bands shall be prepared by lapping a strip of corrugated steel sheet 1 1/2 x 7 inches (40 x 180 mm) with a strip of steel plate 1 1/2 x 7 inches (40 x 180 mm) and joining them together by a single spot weld duplicating the size to be used in production. The steel plate shall be the same thickness as the angles to be used in production. The length of the lap for all tension shear tests shall be 1 1/2 inches (40 mm). The longer axis of the specimen shall be parallel to the direction of rolling. The specimens shall be tested in tension in a standard calibrated testing machine. The minimum shear strength in pounds force (kilonewtons) as determined by this test, shall be as shown in Table XII.

**1020.13.4** After a machine and operator have been qualified by the foregoing procedure, the following additional tests to ensure that qualification is maintained shall be made. Three tension shear tests for pipe shall be made at the start of each work shift. Three tension shear tests shall be made for each change in sheet thickness. Tension shear tests for coupling bands shall be made if requested by the engineer. The results of these tests shall be recorded and shall be available for inspection by the engineer.

**1020.13.5** One copy of the approved machine settings shall be posted on the machine for use by the machine operator. No settings shall be varied, except weld phase shift and pressure which may be varied by not more than 10 percent. If the approved machine settings fail to produce welds of the specified quality within these limits, fabrication shall be stopped until the cause of the trouble is corrected.

**1020.13.6** The fabricator shall mark each length of pipe with the identification number corresponding to the qualifying tension shear test for that machine and operator.

**1020.14 Helical Lock Seams.** Continuous helical lock seams shall be formed in the tangent element of the corrugation profile with its center near the neutral axis of the corrugation profile.

**1020.14.1** The edges of the steel sheet within the cross section of the lock seam shall lap at least 5/16 inch (8 mm) with an occasional tolerance of minus 10 percent of lap width allowable. The lapped surfaces shall be in tight contact.

**1020.14.2** The profile of the steel sheet shall include a retaining offset adjacent to the 180 degree fold, as described in AASHTO T 249, of one sheet thickness on one side of the lock seam or one-half sheet thickness on both sides of the lock seam.

**1020.14.3** There shall be no visible cracks in the metal, loss of metal-to-metal contact or excessive angularity on the interior of the 180 degree fold of metal of finished lock seams.

**1020.14.4** The minimum tensile strength, in pounds force (kilonewtons), as determined on specimens cut from fabricated pipe normal to and across the lock seam shall be as shown in Table XIII.

**1020.14.4.1** When the ends of helically corrugated lock seam pipe have been rerolled to form annular corrugations, the lock seam in the rerolled end shall not contain any visible cracks in the base metal and the tensile strength of the lock seam shall not be less than 60 percent of that required in Table XIII.

**1020.14.5** Sampling and testing for continuous lock seam quality control shall conform to AASHTO T 249. The fabricator shall cut all samples in the presence of the engineer. Visual examination samples shall be cut from at least one pipe of each sheet thickness in each shipment of pipe offered for inspection. In addition, tension test specimens shall be taken from pipe representing each sheet thickness and diameter the first time that sheet thickness and diameter is offered for inspection. Approximately 10 percent of the shipments of each sheet thickness thereafter shall be sampled for tension testing of the seam. If visual examination samples indicate nonconformance, that length of the pipe will be rejected and a resample taken from a different length of pipe of the same sheet thickness of the same diameter. If the resample fails, each shipment of that sheet thickness thereafter shall be sampled for visual examination and tension testing until the engineer determines that satisfactory quality control is established. Pipe from which tension test specimens have been taken may be cut and the undamaged portion accepted for use.

**1020.15 Helical Welded Seams.** Helical continuous welded seams shall be parallel to the corrugations and shall extend from end to end of each length of pipe. Welding shall be by approved methods utilizing ultra high frequency resistance equipment. Seams shall be welded in such a manner that they will develop the full strength of the pipe and not affect shape or nominal diameter of the pipe. Welded seams shall be controlled such that the combined width of weld and adjacent coating burned by welding does not exceed three times the metal thickness. Damage outside the width shall be repaired as required in [Sec 1020.22](#). The manufacturer shall certify that the welds have been tested and found satisfactory.

**1020.15.1** Continuous welded seams shall be tested in accordance with AASHTO T 241, Cup Test Procedure. For a length of pipe to be acceptable, the sum of the lengths of cracks or other defects on either side of the cup shall not exceed 1/4 inch (6 mm). If the first cup indicates a failure, a second test shall be run at another location on the weld not less than 3 inches (75 mm) nor more than 12 inches (300 mm) from the first cup and in the direction of the center of the pipe. If the second test indicates a failure, the pipe shall be rejected.

**1020.15.2** AASHTO T 241, Referee Test Method, shall be used in case of disagreement over the results of the cup test or visual examination.

**1020.15.3** Tests of continuous welded seams shall be made as follows:

**1020.15.3.1** Pipe lengths of 24 feet (7.3 m) or less shall be tested on one end of each length, normally the trailing end.

**1020.15.3.2** Pipe lengths greater than 24 feet (7.3 m) shall be tested on each end of each length of pipe. If either end fails, the entire length will be rejected.

**1020.15.3.3** If a length of pipe having a diameter greater than 48 inches (1200 mm) and length of 24 feet (7.3 m) or less is rejected, the following length of pipe produced shall be tested on both ends. If the test on either end fails, the entire length will be rejected.

**1020.15.4** The requirement for conducting the cup test in accordance with [Sec 1020.15.1](#) shall not apply for pipe with annular rerolled ends. The manufacturer shall maintain visual evaluation of the quality of the weld after rerolling and any indication of weld or base metal failure will be cause for rejection of the pipe.

**1020.15.5** Any cracks, skips or deficient welds found through visual inspection will be cause for rejection unless repaired. The manufacturer may remove the defective portion of the length of pipe or manually repair defects in the automatically welded seam. Altered or repaired pipe shall meet the applicable requirements of [Sec 1020.15.1](#) through [1020.15.4](#). Where a manual repair occurs within 16 inches (400 mm) of the end of a length of pipe, a cup test will be conducted on both the manually repaired section and on the immediately adjacent automatically welded section. If either test results in failure under the requirements of [Sec 1020.15.1](#), the length of pipe will be rejected.

**1020.16 Shop Elongation.** If round pipe is required to be shop elongated, the vertical axis shall be 5 percent greater than the nominal diameter. A tolerance of one percentage point in elongation will be permitted. Approximately 2 feet (600 mm) at each end of an installation may be left round to accommodate connecting end treatments or extensions. A paint mark to indicate the top of pipe shall be placed on each piece of shop elongated pipe and round ends on an elongated pipe shall be clearly marked "Outside End-Round".

**1020.17 End Finish.** Rolled or otherwise reinforced ends will not be required for pipe or pipe-arches.

**1020.17.1** Corrugated metal pipe shown on the plans as having the ends beveled to conform to the adjacent roadway slope shall be cut in such a manner as to leave smooth edges without damage to the coating away from the edges. Cut edges shall be completely covered with two coats of single component inorganic zinc or organic zinc-rich paint meeting the approval of the engineer. No other end finish will be required for pipe having beveled ends.

**1020.17.2** The ends of individual lengths of pipe with helical corrugations may be rerolled to form annular corrugations extending at least two corrugations from the pipe end.

**1020.18 End Sections.** Metal end sections shall comply with the requirements for base metal, coating, fabrication, sampling, accepted brands of metal, sheet manufacturer's certified analysis, sheet manufacturer's guarantee, sheet thickness, workmanship and repair of coating. The sections shall conform to the shape, dimensions and sheet thicknesses shown on the plans. They shall be manufactured as integral units or so they can be readily assembled in place.

**1020.19 Coupling Bands.** Field joints for each type of corrugated steel pipe shall provide circumferential and longitudinal strength to maintain the pipe alignment, prevent separation of pipe and prevent infiltration of side fill material. The coupling bands shall be made of base metal complying with the requirements for steel sheets and shall have the same coating as the sheet used in fabrication of the pipe. Coupling bands shall be not more than three specified sheet thicknesses lighter than the thickness of the pipe to be connected and in no case lighter than a specified thickness of 0.052 inch (1.32 mm). Corrugations in the bands shall have the same dimensions as the corrugations in the pipe ends being connected. Coupling bands may be circumferentially corrugated bands, bands with projections (dimples), formed bands or helical bands.

**1020.19.1** Circumferentially corrugated bands may be used on pipe with annular corrugations and helically corrugated pipe with reformed annular ends. The bands for pipe with 1/2 inch (13 mm) deep corrugations shall be not less than 7 inches (180 mm) wide for diameters 12 to 36 inches (300 to 900 mm), inclusive and not less than 10 1/2 inches (265 mm) wide for all other diameters. Bands for use on pipe fabricated with one inch (25 mm) deep corrugations shall have a minimum width of 12 inches (300 mm).

**1020.19.2** Bands with projections (dimples) may be used on pipe with annular or helical corrugations. The projections shall conform substantially to the shape and depth of the pipe corrugations and shall be in circumferential rows with one projection for each corrugation of helically corrugated pipe. The bands for pipe diameters to 72 inches (1800 mm), inclusive, shall be at least 10 1/2 inches (265 mm) wide and shall have two circumferential rows of projections; and for pipe diameters 78 inches (1950 mm) and greater the bands shall be at least 16 1/4 inches (415 mm) wide and shall have four circumferential rows of projections. Rows of projections shall be spaced to provide equal contact on each of the pipe being joined.

**1020.19.3** Formed bands may be used on pipe with annular corrugations and helically corrugated pipe with reformed ends. The bands shall be formed with two corrugations matching the profile of the pipe being joined together. The corrugations shall be spaced to provide seating in the second corrugation of each pipe and without creating more than 1/2 inch (13 mm) annular space between the pipe ends when joined together.

**1020.19.4** Helical bands for use on helically corrugated pipe shall be not less than 12 inches (300 mm) wide for 1/2 inch (13 mm) deep corrugations and not less than 14 inches (350 mm) wide for one-inch (25 mm) deep corrugations.



**1020.19.5** Circumferentially corrugated bands, bands with projections and helically corrugated bands shall be so constructed as to lap on an equal portion of each of the culvert sections and shall be connected at the ends by galvanized angles having minimum dimensions of 2 x 2 x 3/16 inch (50 x 50 x 5 mm), fastened with galvanized bolts of 1/2-inch (13 mm) minimum diameter. Formed bands shall be fastened together by two 1/2-inch (13 mm) bolts through the use of a bar and strap welded to the band. Angles shall be secured to the coupling bands by riveting or resistance spot welding at each corrugation. Rivets shall be placed so that the head of the rivet will be on the inside of the band. Welds shall be painted with one coat of zinc dust-zinc oxide or zinc-rich paint meeting the approval of the engineer. The 7-inch and 10 1/2-inch (180 mm and 254 mm) bands shall have at least two fastening bolts, the 12-inch and 14-inch (300 mm and 350 mm) bands shall have at least three fastening bolts and the 16 1/4-inch (415 mm) band shall have at least four fastening bolts. Alternate methods of fastening the ends of coupling bands may be used if approved by the engineer. Coupling bands for pipe-arch and shop elongated pipe shall be shaped to fit the structure.

**1020.20 Special Fittings.** Special fittings, angles and tees shown on the plans shall be fabricated by welding in such a manner as to avoid excessive damage to the coating away from the welded area. The welded area and adjacent damaged coating shall be repaired in accordance with [Sec 1020.22](#).

### **Workmanship and Finish**

**1020.21 Workmanship.** In addition to the requirements of fabrication, the completed pipe, bands, fittings or end sections shall show careful, finished workmanship in all particulars. Any item on which the coating has been bruised or broken either in the shop or in shipping or which shows defective workmanship, will be rejected. This requirement applies not only to the individual item, but to the shipment on any contract as a whole. Among others, the following defects are specified as constituting poor workmanship and the presence of any or all of them in any individual pipe, band, fitting, end section or in general in any shipment will constitute sufficient cause for rejection:

- (a) Variation from a straight centerline.
- (b) Elliptical shape in pipe intended to be round.
- (c) Metallic coating which has been bruised, broken or otherwise damaged.
- (d) Lack of rigidity.
- (e) Illegible markings.
- (f) Ragged or diagonal sheared edges or ends.
- (g) Uneven laps in riveted or spot welded pipe.
- (h) Poorly formed rivet heads.
- (i) Loose, unevenly lined or unevenly spaced rivets or spot welds.
- (j) Defective spot welds or continuous welds.
- (k) Dents or bends in the metal.
- (l) Loosely or poorly formed lockseams.

**1020.22 Repair of Damaged Coating.** Units on which the metallic coating has been burned by welding beyond the limits provided in [Sec 1020.13](#) and [1020.15](#) or has been otherwise damaged in fabrication or handling, shall be repaired. The repair shall be done so the completed unit shows careful finished workmanship in all particulars. If the engineer so elects, the repair shall be done in the presence of the engineer. In any case, the material used and the application shall meet the approval of the engineer.

**1020.22.1** Coating damaged during fabrication or handling in the fabricating shop shall be repaired by recoating by the hot-dip process, by the metallizing process or with two coats of single component inorganic zinc or organic zinc-rich paint, meeting the approval of the engineer.

**1020.22.2** Coating damaged in the field shall be repaired by recoating by the hot-dip process or by the metallizing process except that in instances of minor damage to areas in the upper two-thirds of the perimeter as installed, the engineer may permit repair in the same manner as specified for repair during fabrication.

**1020.22.3** Damaged areas shall be cleaned to bright metal by blast cleaning, power disk sanding or wire brushing. The cleaned area shall extend at least 1/2 inch (13 mm) into the undamaged section of the coating. The cleaned area shall be coated within 24 hours and before any rusting or soiling.

**1020.22.4 Repair By Painting.** The type of paint repair may be any one of those specified above. Paint shall be applied over the damaged section and surrounding cleaned undamaged area. Any of the allowed repair paint systems may be used for repair of zinc or aluminum coatings.

**1020.22.5 Repair By Hot-Dip Process.** The fabricated unit shall be thoroughly cleaned prior to recoating. The metallic coating shall then be applied by the hot-dip process in accordance with [Sec 1020.2](#).

**1020.22.6 Repair By Metallizing Process.** The damaged area shall be cleaned as described in [Sec 1020.22.3](#) except the damaged area shall be cleaned to the near-white condition. The repair coating applied to the cleaned section shall have a thickness of not less than 0.005 inch (0.13 mm) over the damaged section and shall taper off to zero thickness at the edges of the cleaned undamaged section.

**1020.22.6.1** When zinc coating is to be metallized, the process shall be done with zinc wire containing not less than 99.98 percent zinc.

**1020.22.6.2** When aluminum coating is to be metallized, the process shall be done with aluminum wire containing not less than 99 percent aluminum.

### **Inspection**

**1020.23 Mill and Factory Inspection.** The engineer may have the material inspected and sampled in the rolling mill or in the shop where fabricated. The engineer may require from the mill the chemical analysis of any heat. The inspection, either in the mill or in the shop, shall be under the direction of the engineer. The engineer shall have free access to the mill or shop for inspection and every facility shall be extended for the purpose of inspection. Any material or pipe which has been previously rejected at the mill or shop and included in a later lot will be considered sufficient cause for rejection of the entire lot.

**1020.24 Field Inspection.** Field inspection will be made by the engineer who shall be furnished by the fabricator an itemized statement of the sizes and lengths of pipe in each shipment. This inspection will include an examination of the pipe for deficiency in specified diameter, net length of finished pipe and any evidence of poor workmanship as outlined in [Sec 1020.21](#). The inspection may include taking samples for chemical analysis, mechanical properties and determination of weight (mass) of coating. The pipe making up the shipment shall meet all requirements of these specifications and if 25 percent of the pipe in any shipment fails to meet these requirements the entire shipment may be rejected.

**1020.24.1** The inspection will include an examination for detrimental defects of broken, peeled and otherwise damaged coating caused by carelessness in handling, transporting, loading or unloading the finished pipe.

### **Marking**

**1020.25** At intervals of 2 to 5 feet (600 to 1500 mm), coated steel sheet in coils or cut lengths shall be identified by a weather resistant stamp showing:

- (a) Name of sheet manufacturer.
- (b) Brand Name.
- (c) Type of coating or AASHTO designation number of the coated steel.
- (d) Specified thickness.
- (e) Specified weight (mass) of coating.
- (f) Identification symbols relating to a specific heat number and coating lot designation.

The identification brands shall be placed on the steel sheet by the manufacturers of the sheet in such way that when fabricated into culverts the markings appear on the outside of the pipe. Each section of riveted or spot-welded pipe shall be marked.

### **Handling**

**1020.26** Proper care shall be exercised in loading, transporting, unloading and delivering the pipe to the construction site and in its placement. When nesting pipe or loading pipe, boards or other suitable material, running the full length of the pipe shall be used to prevent metal from rubbing or resting against metal and to prevent damage to the pipe. Special care shall be exercised in preventing the rivets from scratching adjacent pipe. Chains or metal cables used in binding the load and unloading shall be encased to prevent damaging the pipe or suitable material shall be fastened securely between the pipe and chains or cable. Wood skids or other approved devices shall be used in loading and unloading the pipe. Metal lever bars will not be permitted in loading and unloading. Dragging the pipe across rocky ground or dragging the pipe in such manner as to cause gouging or removal of coating will not be permitted.

<b>TABLE I</b>		
<b>Chemical Composition by Cast Analysis</b>		
<b>Elements</b>	<b>Composition Percent</b>	<b>Tolerance Over the Maximum Limit By Product Analysis, Percent</b>
Sulfur, max	0.05	0.01
Sum of Carbon, Maganese, Phosphorous, Silicon and Sulfur, max	0.70	0.04

<b>TABLE II</b>	
<b>Tensile Requirements</b>	
Tensile strength, min, psi (MPa)	45,000 (310)
Yield point, min, psi (MPa)	33,000 (228)
Elongation in 2 in. (50 mm), min, percent	20

<b>TABLE III</b>		
<b>Specified Thickness, Equivalent Gage and Minimum Thickness</b>		
<b>ENGLISH</b>		
<b>Equivalent Gage</b>	<b>Specified Thickness, Coated Sheet, Inch<sup>a</sup></b>	<b>Minimum Thickness, Inch</b>
18	0.052	0.046
16	0.064	0.057
14	0.079	0.072
12	0.109	0.101
10	0.138	0.129
8	0.168	0.159
<b>Specified Thickness and Minimum Thickness</b>		
<b>METRIC</b>		
<b>Specified Thickness, Coated Sheet mm<sup>a</sup></b>	<b>Minimum Thickness mm</b>	
1.32	1.17	
1.63	1.45	
2.01	1.83	
2.77	2.57	
3.51	3.28	
4.27	4.04	

<sup>a</sup> Thickness is measured at any point on the sheet not less than 3/8 inch (10 mm) from an edge and if corrugated, on the tangents of corrugations.

TABLE IV				
Corrugation Size				
			Inside Radius, Inch (mm)	
Specified Size, Inch (mm)	Maximum Pitch, Inch (mm) <sup>a</sup>	Minimum Depth, Inch (mm) <sup>b</sup>	Specified	Minimum
2 2/3 x 1/2 (68 x 13)	2 7/8 (73)	0.48 (12)	11/16 (17)	0.5 (12)
3 x 1 (75 x 25)	3 1/4 (83)	0.95 (24)	9/16 (14)	0.5 (12)

<sup>a</sup> Pitch is measured from crest to crest of corrugations, at 90 degrees to the direction of the corrugations.

<sup>b</sup> Depth is measured as the vertical distance from a straightedge resting on the corrugation crests to the bottom of the intervening valley.

TABLE V	
Covering Width <sup>a</sup>	
Covering Width, Inch (mm)	Tolerance, Inch (mm)
To 24 (610), inclusive	±1/4 (±6.4)
Over 24 to 36 (610 to 915), inclusive	±3/8 (±9.5)
Over 36 to 48 (915 to 1220), inclusive	±1/2 (±12.7)

<sup>a</sup> This table applies only to corrugated sheet in cut lengths.

TABLE VI		
Edge Lip Dimensions <sup>a</sup>		
Specified Corrugation Size, Inch (mm)	For Riveted Pipe Construction, Inch (mm)	For Spot Welded Pipe Construction, Inch (mm)
2 2/3 x 1/2 (68 x 13)	3/4 (19) + 3/16 (4.8) - 0	7/16 (11) min
3 x 1 (75 x 25)	7/8 (22) + 3/16 (4.8) - 0	1/2 (13) min

<sup>a</sup> This table applies to corrugated sheet in cut lengths for the type of fabrication shown.

TABLE VII	
Aluminum Bath Analysis	
Elements	Composition, Percent
Iron, max	3.0
Silicon, max	0.35
Magnesium, max	0.50
Other, each, max	0.05
Other, total, max	0.20

TABLE VIII			
Pipe Requirements			
Specified Inside Diameter, Inch (mm) <sup>a</sup>	Specified Corrugation Pitch, Inch (mm) <sup>b</sup>	Specified Corrugation Depth, Inch (mm) <sup>c</sup>	Width of Lap Inch (mm), Minimum
12 (300)	2 2/3 (68)	1/2 (13)	1 1/2 (38)
15 (375)	2 2/3 (68)	1/2 (13)	1 1/2 (38)
18 (450)	2 2/3 (68)	1/2 (13)	1 1/2 (38)
21 (525)	2 2/3 (68)	1/2 (13)	1 1/2 (38)
24 (600)	2 2/3 (68)	1/2 (13)	1 1/2 (38)
30 (750)	2 2/3 (68)	1/2 (13)	1 1/2 (38)
36 (900)	2 2/3 (68)	1/2 (13)	1 1/2 (38)
	3 (75)	1 (25)	3 (75)
42 (1050)	2 2/3 (68)	1/2 (13)	3 (75)
	3 (75)	1 (25)	
48 (1200)	2 2/3 (68)	1/2 (13)	3 (75)
	3 (75)	1 (25)	
54 (1350)	2 2/3 (68)	1/2 (13)	3 (75)
	3 (75)	1 (25)	
60 (1500)	2 2/3 (68)	1/2 (13)	3 (75)
	3 (75)	1 (25)	
66 (1650)	2 2/3 (68)	1/2 (13)	3 (75)
	3 (75)	1 (25)	
72 (1800)	2 2/3 (68)	1/2 (13)	3 (75)
	3 (75)	1 (25)	
78 (1950)	2 2/3 (68)	1/2 (13)	3 (75)
	3 (75)	1 (25)	
84 (2100)	2 2/3 (68)	1/2 (13)	3 (75)
	3 (75)	1 (25)	
90 (2250)	3 (75)	1 (25)	3 (75)
96 (2400)	3 (75)	1 (25)	3 (75)
102 (2550)	3 (75)	1 (25)	3 (75)
108 (2700)	3 (75)	1 (25)	3 (75)
114 (2850)	3 (75)	1 (25)	3 (75)
120 (3000)	3 (75)	1 (25)	3 (75)

<sup>a</sup> The average inside diameter of circular pipe and pipe to be reformed into pipe-arches shall not vary more than 1/2 inch (13 mm) from the specified diameter when measured on the inside crest of the corrugations for diameters through 48 inches (1200 mm) and one percent for diameters greater than 48 inches (1200 mm). In no case shall the difference in diameter of the abutting pipe ends be more than 1/2 inch (13 mm).

<sup>b</sup> Circular pipe 54 inches (1350 mm) or more in diameter shall be shop elongated. Circular pipe 48 inches (1200 mm) in diameter may be furnished round or shop elongated in accordance with [Sec 725](#).

<sup>c</sup> Measured on outside at right angle to a line parallel to axis of pipe. The depth of the corrugations shall not underrun that specified by more than 5 percent.

Unless otherwise provided on the plans or in the contract, the minimum thickness listed in Table I, [Sec 725](#), for a specified diameter may be furnished.

TABLE IX						
Pipe-Arch Requirements						
ENGLISH						
2 2/3 x 1/2 Inch Corrugations						
Type	Span, Inches <sup>a</sup>	Rise, Inches <sup>a</sup>	Diameter Equivalent Pipe, Inches <sup>b</sup>	Minimum Corner Radius, Inches	Maximum B, Inches <sup>c</sup>	Galvanized Sheet Thickness, Inch (Gage)
B5	35	24	30	3	9 1/2	0.064(16)
B6	42	29	36	3 1/2	10 1/2	0.079(14)
B7	49	33	42	4	11 1/2	0.109(12)
B8	57	38	48	5	13 1/2	0.109(12)
B9	64	43	54	6	15	0.109(12)
B10	71	47	60	7	16 1/2	0.138(10)
B11	77	52	66	8	18	0.168(8)
B12	83	57	72	9	20	0.168(8)
METRIC						
68 x 13 mm Corrugations						
Type	Span, mm <sup>a</sup>	Rise, mm <sup>a</sup>	Diameter Equivalent Pipe, mm <sup>b</sup>	Minimum Corner Radius, mm	Maximum B, mm <sup>c</sup>	Galvanized Sheet Thickness, mm
B5	885	610	750	75	240	1.63
B6	1060	740	900	90	265	2.01
B7	1240	840	1050	100	290	2.77
B8	1440	970	1200	130	345	2.77
B9	1620	1100	1350	155	380	2.77
B10	1800	1200	1500	180	420	3.51
B11	1950	1320	1650	205	460	4.27
B12	2100	1450	1800	230	510	4.27

<sup>a</sup> A tolerance of plus or minus one inch (25 mm) or 2 percent of equivalent circular diameter, whichever is greater, will be permissible in span and rise.

<sup>b</sup> Pipe requirements shown in Table VIII.

<sup>c</sup> B is defined as the vertical dimension from a horizontal line across the widest portion of the arch to the lowest portion of the base.

All dimensions are measured from the inside crests of the corrugations and the shape shall be essentially of the pipe-arch configuration.

Ends of joining sections shall be of the same geometry and shall be adaptable to the coupling bands specified in [Sec 1020.19](#).

TABLE X						
Pipe-Arch Requirements						
ENGLISH						
3 x 1 Inch Corrugations						
Type	Pipe-Arch Size, Inches	Diameter Equivalent Pipe, Inches <sup>a</sup>	Span, Inches <sup>b</sup>	Rise, Inches <sup>b</sup>	Minimum Corner Radius, Inches	Galvanized Sheet Thickness, Inch (Gage)
B6A	40x31	36	40-1.8	31+1.8	5	0.079(14)
B7A	46x36	42	46-2.1	36+2.1	6	0.079(14)
B8A	53x41	48	53-2.4	41+2.4	7	0.079(14)
B9A	60x46	54	60-2.7	46+2.7	8	0.079(14)
B10A	66x51	60	66-3.0	51+3.0	9	0.079(14)
B11A	73x55	66	73-3.3	55+3.3	12	0.079(14)
B12A	81x59	72	81-3.6	59+3.6	14	0.079(14)
B13A	87x63	78	87-4.4	63+4.4	14	0.079(14)
B14A	95x67	84	95-4.8	67+4.8	16	0.079(14)
B15A	103x71	90	103-5.2	71+5.2	16	0.079(14)
B16A	112x75	96	112-5.6	75+5.6	18	0.109(12)
B17A	117x79	102	117-5.9	79+5.9	18	0.109(12)
B18A	128x83	108	128-6.4	83+6.4	18	0.109(12)
B19A	137x87	114	137-6.9	87+6.9	18	0.109(12)
B20A	142x91	120	142-7.1	91+7.1	18	0.138(10)
METRIC						
75 x 25 mm Corrugations						
Type	Pipe-Arch Size, mm	Diameter Equivalent Pipe, mm <sup>a</sup>	Span, mm <sup>b</sup>	Rise, mm <sup>b</sup>	Minimum Corner Radius, mm	Galvanized Sheet Thickness, mm
B6A	1010x790	900	1010-45	790+45	130	2.0
B7A	1160x920	1050	1160-55	920+55	155	2.0
B8A	1340x1050	1200	1340-60	1050+60	180	2.0
B9A	1520x1170	1350	1520-70	1170+70	205	2.0
B10A	1670x1300	1500	1670-75	1300+75	230	2.0
B11A	1850x1700	1650	1850-85	1400+85	305	2.0
B12A	2050x1500	1800	2050-95	1500+95	355	2.0
B13A	2200x1620	1950	2200-110	1620+110	355	2.0
B14A	2400x1720	2100	2400-120	1720+120	410	2.0
B15A	2600x1820	2250	2600-130	1820+130	410	2.0
B16A	2980x1920	2400	2840-145	1920+145	460	2.8
B17A	2970x2020	2550	2970-150	2020+150	460	2.8
B18A	3240x2120	2700	3240-165	2120+165	460	2.8
B19A	3470x2220	2850	3470-175	2220+175	460	2.8
B20A	3600x2320	3000	3600-180	2320+180	460	3.5

<sup>a</sup> Pipe requirements shown in Table VIII.

<sup>b</sup> Minus and plus figures in span and rise are tolerances.

All dimensions are measured from the inside crest of corrugations and the shape shall be essentially of the pipe-arch configurations.



Ends of joining sections shall be of the same geometry and shall be adaptable to the coupling bands specified in [Sec 1020.19](#).

<b>TABLE X</b>		
<b>Riveted and Spot Welded Seams</b>		
<b>Specified Sheet Thickness, inch (mm)</b>	<b>Rivet or Spot Weld Diameter, inch (mm), min</b>	
	<b>2 2/3 x 1/2 in. (68 x 13 mm)</b>	<b>3 x 1 in. (75 x 25 mm)</b>
	<b>Corrugation</b>	<b>Corrugation</b>
0.052 (1.32)	5/16 (8.0)	....
0.064 (1.63)	5/16 (8.0)	3/8 (9.5)
0.079 (2.01)	5/16 (8.0)	3/8 (9.5)
0.109 (2.77)	3/8 (9.5)	7/16 (11.0)
0.138 (3.51)	3/8 (9.5)	7/16 (11.0)
0.168 (4.27)	3/8 (9.5)	7/16 (11.0)

<b>TABLE XII</b>	
<b>Shear Strength of Spot Welds</b>	
<b>Specified Sheet Thickness, Inch (mm)</b>	<b>Pounds Force (kN), Minimum</b>
0.064 (1.63)	4100 (18.2)
0.079 (2.01)	5200 (23.1)
0.109 (2.77)	7000 (31.1)
0.138 (3.51)	8500 (37.8)
0.168 (4.27)	10,000 (44.5)

<b>TABLE XIII</b>	
<b>Tensile Strength of Lock Seams</b>	
<b>Specified Sheet Thickness, Inch (mm)</b>	<b>Pounds Force Per Inch (kN/mm) of Width, Minimum</b>
0.064 (1.63)	425 (74)
0.079 (2.01)	650 (114)
0.109 (2.77)	875 (153)
0.138 (3.50)	1100 (193)
0.168 (4.27)	1500 (263)

## SECTION 1021

### BITUMINOUS COATED CORRUGATED METAL CULVERT PIPE AND PIPE ARCHES

**1021.1 Scope.** This specification covers bituminous coated corrugated metal culvert pipe and pipe-arches, to be used for the construction of culverts.

**1021.2 Types of Coated Pipe.** The coated pipe shall be one of the following types as specified in the contract:

Type A. Fully Bituminous Coated.

Type B. Half Bituminous Coated, Paved-invert.

Type C. Fully Bituminous Coated, Paved-invert.

**1021.3 Corrugated Metal Culvert Pipe and Pipe-Arches.** Pipe and pipe-arches shall conform to the requirements of [Sec 1020](#) or [1024](#), as specified. Lift hooks or loops, if agreed upon by the engineer and manufacturer, may be attached to pipe and pipe-arches to facilitate handling.

**1021.4 Coating Requirements.** Pipe and pipe-arches shall be coated with bituminous material as follows for the particular type specified in the contract:

Type A. The pipe shall be uniformly coated, inside and outside, to a minimum thickness of 0.05 inch (1.3 mm) measured on the crest of the corrugations.

Type B. The pipe shall be uniformly coated for approximately one-half the circumference of the pipe (bottom of the pipe when installed), inside and outside to a minimum thickness of 0.05 inch (1.3 mm) measured on the crest of the corrugations. In addition, the bituminous material shall be applied in such manner that one or more smooth pavements will be formed in the invert (inside bottom of the pipe when installed), filling the corrugations for at least 25 percent of the circumference of a pipe and 40 percent of the circumference of a pipe-arch. The pavement shall have a minimum thickness of 1/8 inch (3 mm) measured on the crest of the corrugations, except where the upper edges intersect the corrugations.

Type C. The pipe shall be fully coated as required for Type A and, in addition, a smooth pavement shall be provided as required for Type B.

**1021.5 Bituminous Material.** The bituminous material shall conform to the requirements of AASHTO M 190 except acceptance may be based on samples obtained from storage or from the dipping tanks.

**1021.6 Repair of Damaged Bituminous Coating.** Bituminous coating damaged or displaced during delivery or installation shall be repaired as directed by the engineer by application of hot bituminous material of the same type as that originally used. Care shall be taken to avoid damage to the bituminous material during heating.

## SECTION 1022

### CORRUGATED METALLIC-COATED STEEL PIPE UNDERDRAIN

**1022.1 General.** Corrugated metallic-coated steel underdrain shall conform to the requirements of AASHTO M 36 for zinc-coated or aluminum-coated Type III pipe, with the following modifications:

(a) Pipe 6 inches (150 mm) in diameter shall be fabricated of steel not less than 0.052 inch, 18 gage, (1.32 mm) specified thickness. Pipe 8 to 21 inches (200 to 525 mm), inclusive, in diameter shall be fabricated of steel not less than 0.064 inch, 16 gage, (1.63 mm) specified thickness.

(b) Coupling bands shall be of the same base metal as the pipe.

(c) Mechanical requirements of the base metal shall not apply.

(d) Samples for determination of coating thickness may be taken from fabricated pipe.

**1022.2 Perforations.** Unless otherwise specified, all pipe shall be perforated in accordance with the requirements for Class 1 perforations AASHTO M 36.

## SECTION 1023

### STRUCTURAL PLATE PIPE AND PIPE-ARCHES

**1023.1 Scope.** This specification covers corrugated galvanized steel structural plates intended for use in construction of pipe and pipe-arches. The plates shall consist of corrugated galvanized metal and shall be curved so that they can be bolted together to form a structure of the specified shape and size.

**1023.2 Base Metal.** The plates shall be fabricated from base metal made by the open hearth, basic oxygen or electric furnace process. The base metal cast analysis shall conform to the chemical requirements shown in Table I.

TABLE I		
Chemical Composition by Cast Analysis		
Element	Composition Percent, Max	Tolerance Over the Max Limit By Product Analysis, Percent
Sulfur	0.05	+0.01
Sum of Carbon, Manganese, Phosphorus, Silicon and Sulfur	0.70	+0.04

**1023.3 Corrugations.** The corrugations shall form smooth continuous curves and tangents. The radii of curvature of the corrugations shall be at least one-half the depth of the corrugations. Corrugations shall form circumferential rings complete or partial about the axis of the structure. The corrugations shall have a depth of 2 inches (50 mm) and a pitch of 6 inches (150 mm). The depth of corrugations shall not underrun that specified by more than 5 percent and the pitch shall not deviate from that specified by more than 1/4 inch (6 mm).

**1023.4 Thickness Determination and Tolerances.** The thickness of the plates will be determined from the thickness of the fabricated galvanized plates and will be measured on the tangents of the corrugations. The specified thickness and the permissible variations for each thickness shall be as shown in Table II.

TABLE II	
Sheet Thickness	
Specified Thickness, Inch (mm)	Minimum Thickness, inch (mm) <sup>a</sup>
0.111 (2.5)	0.099 (2.5)
0.140 (3.5)	0.128 (3.3)
0.170 (4.5)	0.158 (4.0)
0.188 (5.0)	0.176 (4.5)
0.218 (5.5)	0.206 (5.2)
0.249 (6.5)	0.237 (6.0)
0.280 (7.0)	0.268 (6.8)

<sup>a</sup> No limit on over thickness.

**1023.5 Spelter Coating.** A coating of prime western spelter or equal shall be applied to each plate by the hot-dip process to provide an average coating weight (mass) of 3.0 ounces per square foot (910 g/m<sup>2</sup>) of sheet (total both surfaces) and a minimum coating weight (mass) for any single specimen of 2.7 ounces per square foot (820 g/m<sup>2</sup>) of sheet. The spelter coating shall be free from injurious defects such as blisters, flux and uncoated spots.

**1023.6 Galvanized Plates.** The corrugated plates may be fabricated from galvanized sheets or plates and no further galvanizing will be required after fabrication if the spelter coating has not been damaged in the fabrication process.

**1023.7 Sampling.** For testing the weight (mass) of spelter coating and for chemical analysis, if required, a sample shall be provided for each 100 plates of each thickness of a shipment or fraction thereof. This sample may be obtained from a piece approximately 3 inches (75 mm) square, cut from a corner of a plate or from a coupon approximately 6 inches (150 mm) square attached to the center of one edge of the plate prior to galvanizing. The coupon shall be of the same thickness and base metal as the plate to which the coupon is attached. If the result of a test for weight (mass) of coating for any sample does not conform to the requirements specified, an additional sample shall be cut for tests from each of two other plates in the lot represented by the nonconforming sample. All original samples and samples for retest shall average not less than that specified as average coating in Table III and no sample shall have less than that specified as minimum check limit in Table III or the entire shipment will be rejected. At the option of the engineer, the material may be accepted or rejected on the basis of magnetic gauge results, however plates rejected by magnetic gauge results will be sampled as specified above, at the request of the contractor or fabricator.

**1023.8 Accepted Brands of Metal.** No metal will be accepted under these specifications for the material described above until after the fabricator's certificate and guarantee has been approved by the engineer.

**1023.8.1 Fabricator's Certificate.** The fabricator of the structural plate identified by the fabricator's mark shall file with the Division Engineer, Materials, a certificate setting forth the name of the fabricator, the base metal manufacturer, the specified chemical composition and a typical or average analysis showing the percent of sulfur, copper and any other elements specified in Table I. The certificate shall be sworn to for the fabricator by a person having legal authority to bind the company. Mismatching or other misrepresentation by the fabricator will be considered a sufficient reason to discontinue acceptance under these specifications. Notice sent to the fabricator of the discontinuance of acceptance will be considered to be notice to all companies which handle that particular fabricator's product.

**1023.8.2 Fabricator's Guarantee.** The fabricator of the structural plate shall submit with the certificate a guarantee providing that all structural plate furnished shall conform to the specification requirements, shall bear the fabricator's identification mark and shall be replaced without cost when not in conformity with the specified analysis, sheet thickness or spelter coating. The guarantee shall be so worded as to remain in effect so long as the fabricator continues to furnish the material.

**1023.9 Identification.** No plates will be accepted unless the metal has weather resistant identification on each plate showing:

- (a) Name of plate fabricator.
- (b) Specified galvanized plate thickness.
- (c) Specified weight (mass) of coating.

(d) Identification symbols showing sheet manufacturer and heat number or lot number.

The identification shall be so placed that when the pipe or pipe-arch is erected, the identification will appear on the inside of the structure.

#### **1023.10 Bolts and Nuts for Connecting Plates.**

**1023.10.1** Bolts for connecting plates shall be 3/4 inch (19 mm) in diameter and shall meet the requirements of ASTM A 449. Nuts shall conform to the requirements of ASTM A 563, Grade C. Bolts, nuts and washers shall be galvanized in accordance with the requirements of AASHTO M 232 or they may be mechanically galvanized. If mechanically galvanized, the coating thickness, adherence and quality requirements shall conform to AASHTO M 232, Class C. Except as specified herein, bolts and nuts shall meet the dimension requirements of ANSI B18.2.1 for heavy hex bolts and B18.2.2 for heavy hex nuts with the exception that the bearing surface of both bolts and nuts shall be symmetrically shaped to a one-inch (25 mm) radius spherical surface. The maximum height of the wrench flats on bolts and thickness of nuts shall be within the limits specified in B18.2.1 and B18.2.2, respectively. Bolt lengths shall be such as to result in at least "full nuts" when tightened in place. The bolts and nuts may be sampled and tested before erection or they may be accepted on certified mill tests by the manufacturer.

**1023.10.2** Other fasteners which meet the chemical and mechanical requirements of those specified in [Sec 1023.10.1](#) and which have body diameter and bearing areas not less than those described in [Sec 1023.10.1](#) and which provide a comparable fit with the corrugations may be used.

#### **1023.11 Manufacture.**

**1023.11.1 General Requirements.** The plates shall be connected by bolts at longitudinal and circumferential seams. Joints shall be staggered so that not more than three plates come together at any one point. Plates shall be furnished in standard sizes to permit structure length increments of 2 feet (600 mm). The size and shape of the plates shall be such that the finished structure will have the dimensions shown on the plans or as specified herein and such that the transverse (circumferential or peripheral) seams will be staggered at least one foot (300 mm), except that the engineer may permit the seams in adjacent plates used for construction of beveled or skewed ends to be continuous. At least four bolts shall be used per foot (300 mm) of longitudinal seam, unless a greater number is specified on the plans, staggered in two rows 2 inches (50 mm) apart, with one row in the valleys and one row on the crests of the corrugations. Bolts along circumferential seams shall be spaced not more than 10 inches (250 mm) apart. Bolt holes shall be so punched that all plates of like size and shape, except end plates, will be interchangeable. The distance from the center of bolt hole to the edge of the plate shall not be less than 1 3/4 times the diameter of the bolt. The diameter of the bolt holes for the longitudinal seams, except holes at corners of plates, shall not exceed the diameter of the bolts by more than 1/4 inch (6 mm). The major axis of the holes for transverse seams, including the holes at the corners of the plates, shall not exceed the diameter of the bolt by more than 1/2 inch (13 mm) and the average of the major and minor axis shall not exceed the diameter of the bolt by more than 1/4 inch (6 mm).

**1023.11.2 Circular Pipe.** A manufacturing tolerance of 3 inches (75 mm) will be permitted in the diameter of the pipe. The thickness of metal to be used for each structure will be specified in the contract. Round pipe shall be shop-elongated. The plates shall be formed so that the finished pipe is elliptical in shape with the vertical diameter 5 percent, plus or minus

one percentage point, greater than the nominal diameter of the pipe. The plates shall be prominently marked to show the position in which they are to be placed in the structure.

**1023.11.3 Pipe-Arch.** Plates for a pipe-arch shall form a cross section made up of four circular arcs tangent to each other at their junctions and symmetrical about the vertical axis. The top shall be an arc of not more than 180 degrees nor less than 155 degrees. The bottom shall be an arc of not more than 50 degrees nor less than 10 degrees. The top shall be joined at each end to the bottom by an arc of not more than 87 1/2 degrees nor less than 75 degrees. The radius of corner arcs shall be between 16 and 21 inches (400 and 525 mm) for Type C-29 and smaller sizes and between 29 and 33 inches (725 and 825 mm) for Type C-30 and larger sizes. The dimensions of structural plate pipe-arch shall be as specified in Table IV subject to a manufacturing tolerance of 2 percent plus one inch (25 mm). The thickness of metal to be used for each structure will be specified in the contract.

TABLE IV							
Structural Plate Pipe-Arch							
ENGLISH							
Type	Area, Sq Ft	Span, Ft-In.	Height, Ft-In.	Type	Area, Sq Ft	Span, Ft-In.	Height, Ft-In.
C-1	22	6-1	4-7	C-28	105	14-10	9-1
C-2	24	6-4	4-9	C-29	109	15-4	9-3
C-3	26	6-9	4-11	C-30	98	13-3	9-4
C-4	28	7-0	5-1	C-31	102	13-6	9-6
C-5	31	7-3	5-3	C-32	106	14-0	9-8
C-6	33	7-8	5-5	C-33	110	14-2	9-10
C-7	35	7-11	5-7	C-34	115	14-5	10-0
C-8	38	8-2	5-9	C-35	119	14-11	10-2
C-9	40	8-7	5-11	C-36	124	15-4	10-4
C-10	43	8-10	6-1	C-37	129	15-7	10-6
C-11	46	9-4	6-3	C-38	133	15-10	10-8
C-12	49	9-6	6-5	C-39	138	16-3	10-10
C-13	52	9-9	6-7	C-40	143	16-6	11-0
C-14	55	10-3	6-9	C-41	148	17-0	11-2
C-15	58	10-8	6-11	C-42	153	17-2	11-4
C-16	61	10-11	7-1	C-43	158	17-5	11-6
C-17	64	11-5	7-3	C-44	163	17-11	11-8
C-18	67	11-7	7-5	C-45	168	18-1	11-10
C-19	71	11-10	7-7	C-46	174	18-7	12-0
C-20	74	12-4	7-9	C-47	179	18-9	12-2
C-21	78	12-6	7-11	C-48	185	19-3	12-4
C-22	81	12-8	8-1	C-49	190	19-6	12-6
C-23	85	12-10	8-4	C-50	196	19-8	12-8
C-24	89	13-5	8-5	C-51	202	19-11	12-10
C-25	93	13-11	8-7	C-52	208	20-5	13-0
C-26	97	14-1	8-9	C-53	214	20-7	13-2
C-27	101	14-3	8-11	....	....	....	....

METRIC							
Type	Area, m <sup>2</sup>	Span, mm	Height, mm	Type	Area, m <sup>2</sup>	Span, mm	Height, mm
C-1	2.0	1850	1400	C-28	9.8	4500	2750
C-2	2.2	1950	1450	C-29	10.1	4700	2800
C-3	2.4	2050	1500	C-30	9.1	4050	2850
C-4	2.6	2150	1550	C-31	9.5	4100	2900
C-5	2.9	2200	1600	C-32	9.8	4250	2950
C-6	3.1	2350	1650	C-33	10.2	4300	3000
C-7	3.3	2400	1700	C-34	10.7	4400	3050
C-8	3.5	2500	1750	C-35	11.1	4550	3100
C-9	3.7	2600	1800	C-36	11.5	4650	3150
C-10	4.0	2700	1850	C-37	12.0	4750	3200
C-11	4.3	2850	1900	C-38	12.4	4800	3250
C-12	4.6	2900	1950	C-39	12.8	4950	3300
C-13	4.8	3000	2000	C-40	13.3	5050	3350
C-14	5.1	3100	2050	C-41	13.7	5200	3400
C-15	5.4	3250	2100	C-42	14.2	5250	3450
C-16	5.7	3350	2150	C-43	14.7	5300	3500
C-17	5.9	3500	2200	C-44	15.1	5450	3550
C-18	6.2	3550	2250	C-45	15.6	5500	3600
C-19	6.6	3600	2300	C-46	16.2	5650	3650
C-20	6.9	3750	2350	C-47	16.6	5700	3700
C-21	7.2	3800	2400	C-48	17.2	5850	3750
C-22	7.5	3850	2450	C-49	17.7	5950	3800
C-23	7.9	3900	2550	C-50	18.2	6000	3850
C-24	8.3	4050	2550	C-51	18.7	6050	3900
C-25	8.6	4250	2600	C-52	19.3	6200	3950
C-26	9.0	4300	2650	C-53	19.9	6300	4000
C-27	9.4	4350	2700	....	....	....	....

**1023.11.4 Beveled Ends.** End plates for forming beveled ends, when so specified on the plans, shall be shaped to produce the specified slope in the finished structure. Burnt edges shall be free from oxide and burrs and shall present a workmanlike finish. Any edges cut after galvanizing, shall be completely covered with two coats of single component inorganic zinc or organic zinc-rich paint, meeting the approval of the engineer. Legible identification marks shall be placed on each part plate to designate its proper position in the structure.

**1023.12 Workmanship.** All plates shall show careful and finished workmanship. Among others, the following defects are specified as constituting poor workmanship and the presence of any or all of them in an individual plate or in general in any shipment, will constitute sufficient cause for rejection:

- (a) Improper shape.
- (b) Ragged edges.
- (c) Unevenly lined or spaced bolt holes.
- (d) Illegible brands.
- (e) Bruised, scaled or broken spelter coating.



(f) Dents or bends in the metal itself.

**1023.13 Field Inspection and Acceptance of Plates.** The field inspection will be made by the engineer, who shall be furnished an itemized statement of the number and length of the plates in each shipment. Each plate included in a shipment shall meet all of the requirements of these specifications. If 25 percent of the plates in any shipment fail to meet the requirements the entire shipment may be rejected.

**1023.14 Assembly Instructions and Drawings.** The contractor shall provide the engineer with detailed assembly instructions and drawings for each structural plate pipe or pipe-arch prior to the installation of these structures.

**1023.15 Repair of Galvanizing.** Spelter coating damaged in the field shall be repaired by hot-dip galvanizing, the metallizing process as specified in [Sec 1020](#) or by the zinc alloy stick method in accordance with [Sec 712.14](#) except that in instances of minor damage, the engineer may permit repair by painting with two coats of single component inorganic zinc or organic zinc-rich paint. The paint and application shall meet the approval of the engineer.

## **SECTION 1024**

### **CORRUGATED ALUMINUM ALLOY CULVERT PIPE AND CORRUGATED ALUMINUM ALLOY STRUCTURAL PLATE**

**1024.1 Corrugated Aluminum Alloy Culvert Pipe.** This pipe shall conform to the requirements of AASHTO M 196, Type I.

**1024.2 Corrugated Aluminum Alloy Structural Plate.** Plates, shapes and fasteners for aluminum alloy field bolted pipe and pipe-arch shall conform to the requirements of AASHTO M 219.

## SECTION 1025

### CORRUGATED ALUMINUM ALLOY PIPE UNDERDRAINS

**1025.1 Corrugated Aluminum Alloy Pipe Underdrains.** This pipe shall conform to the requirements of AASHTO M 196, Type III, with the following modifications:

(a) Pipe 6 inches (150 mm) in diameter shall be fabricated of metal not less than 0.048 inch, 18 gage, (1.2 mm) specified thickness. Pipe 8 to 21 inches (200 to 525 mm), inclusive, in diameter shall be fabricated of metal not less than 0.060 inch, 16 gage, (1.5 mm) specified thickness.

(b) Coupling bands shall be of the same aluminum alloy as the pipe.

## SECTION 1026

### REINFORCED CONCRETE CULVERT, STORM DRAIN AND SEWER PIPE

**1026.1 Scope.** These specifications cover reinforced concrete pipe to be used for the conveyance of sewage, industrial wastes and storm water and for the construction of culverts.

**1026.2 Classes.** Pipe manufactured according to these specifications shall be of five classes identified as Class I, Class II, Class III, Class IV and Class V. The corresponding strength requirements are specified in Tables I to V.

#### **1026.3 Basis of Acceptance.**

**1026.3.1** Unless otherwise specified in the contract, two separate and alternate bases of acceptance are permitted as follows:

**1026.3.1.1 Acceptance on Basis of Plant Load Bearing Tests, Material Tests and Inspection of the Manufactured Pipe for Visual Defects and Imperfections.** Acceptability of the pipe in all diameters and classes produced in accordance with [Sec 1026.9](#) or [1026.10](#) shall be determined by the results of the three-edge bearing tests for either the load to produce a 0.01-inch (0.3 mm) crack or at the option of the engineer, the load to produce a 0.01-inch (0.3 mm) crack and the ultimate strength of the pipe; by such material tests as are required in [Sec 1026.5](#), [1026.6](#) and [1026.7](#); by absorption tests on selected samples of concrete from the wall of the pipe; and by visual inspection of the finished pipe to determine conformance with the accepted design and freedom from defects.

**1026.3.1.2 Acceptance on Basis of Material Tests and Inspection of Manufactured Pipe for Defects and Imperfections.** Acceptability of the pipe in all diameters and classes shall be determined by the results of such material tests as are required in [Sec 1026.5](#), [1026.6](#) and [1026.7](#); by crushing tests on concrete cores or cured concrete cylinders; by absorption tests on selected samples from the wall of the pipe; and by inspection of the finished pipe, including quantity and placement of reinforcement, to determine conformance with the accepted design and freedom from defects.

**1026.3.1.3** The engineer may select and have applied the basis of acceptance in either [Sec 1026.3.1.1](#) or [1026.3.1.2](#).

**1026.3.2 Age for Acceptance.** Pipe will be considered ready for acceptance when the pipe conforms to the requirements, as indicated by the specified tests.

#### **Material**

**1026.4 Reinforced Concrete.** The reinforced concrete shall consist of a mixture of cement, mineral aggregates and water, in which steel has been embedded in such manner that the steel and the concrete act together. Fly ash may be used to replace cement in accordance with the applicable provisions of [Sec 501](#).

**1026.5 Cement.** Cement shall conform to the requirements of [Sec 1019](#).

**1026.6 Steel Reinforcement.** Reinforcement may consist (1) of wire conforming to AASHTO M 32 or AASHTO M 225, (2) of wire fabric conforming to AASHTO M 55 or

AASHTO M 221, except the requirements for weld shear tests and the variation of diameter of transverse wires shall be waived or (3) of bars conforming to AASHTO M 31.

**1026.7 Aggregates.** Fine and coarse aggregates shall conform to the requirements of [Sec 1005](#), except that requirements for gradation and percent passing the No. 200 (75  $\mu\text{m}$ ) sieve shall not apply.

**1026.8 Mixture.** The aggregates shall be sized, graded, proportioned and thoroughly mixed in a batch mixer with such proportions of cement and water as will produce a homogeneous concrete mixture of such quality that the pipe will conform to the test and design requirements. Admixtures or blends may be used with the approval of the engineer. In no case, however, shall the proportion of cement in the mixture be less than 564 pounds per cubic yard (335  $\text{kg/m}^3$ ) of concrete.

### Design

**1026.9 Design Tables.** The diameter, wall thickness, compressive strength of the concrete and the quantity of the circumferential reinforcement shall be as prescribed for Classes I to V in Tables I to V, subject to the provisions of [Sec 1026.10](#), [1026.11](#), [1026.21](#) and [1026.23](#).

**1026.10 Modified or Special Designs.** The manufacturer may request approval of modified designs which differ from the designs in [Sec 1026.9](#); or special designs for sizes and loads beyond those shown in Tables I to V; or special designs for pipe sizes that do not have steel reinforcement areas shown in Tables II to V.

**1026.10.1** Such modified or special designs shall be based on rational or empirical evaluations of the ultimate strength and cracking behavior of pipe and shall fully describe to the engineer any deviations from the requirements of [Sec 1026.9](#). The descriptions of modified or special designs shall include the wall thickness, the concrete strength and the area, type, placement, number of layers and strength of the steel reinforcement.

**1026.10.2** The manufacturer shall submit to the engineer proof of the adequacy of the proposed modified or special design. Such proof may comprise the submission of properly certified three-edge bearing tests already made, which are found by the engineer to be adequate or, if such three-edge bearing tests are not available or acceptable, the manufacturer may be required to perform proof tests on sizes and classes selected by the engineer to demonstrate the correctness and adequacy of the proposed design.

**1026.10.3** Such pipe shall meet all of the test and performance requirements specified by the engineer in accordance with [Sec 1026.3](#).

### 1026.11 Placing Reinforcement.

**1026.11.1** Where one line of circular reinforcement is used, the reinforcement shall be placed from 35 to 50 percent of the wall thickness from the inner surface of the pipe except that for wall thicknesses less than 2 1/2 inches (63 mm), the protective cover of the concrete over the circumferential reinforcement in the wall of the pipe shall be 3/4 inch (19 mm). In circular pipe having two lines of circular reinforcement, each line shall be so placed that the protective covering of concrete over the circumferential reinforcement in the wall of the pipe shall be one inch (25 mm). In circular pipe having elliptical reinforcement with wall thickness 2 1/2 inches (63 mm) or over, the reinforcement in the wall of the pipe shall be so placed that the protective covering of concrete over the circumferential reinforcement along the vertical diameter of the pipe shall be one inch (25 mm) from the inside surface of the pipe and the protective covering of concrete over the circumferential reinforcement along the horizontal diameter of the pipe

shall be one inch (25 mm) from the outside surface of the pipe. In all pipe 36 inches (900 mm) or more in diameter, the bell or the spigot of the joint shall contain circumferential reinforcement. For double-cage pipe, reinforcement shall be at least equal in area to that of the outside cage or line for bells or the inside cage or line for spigots. For single-cage pipe, reinforcement shall be at least equal in area to that of the cage for either the bell or spigot. The location of the reinforcement shall be subject, to the permissible variations in dimensions given in [Sec 1026.23](#).

**1026.11.2** A line of circumferential reinforcement of any given total area may be composed of two layers for pipe with wall thickness of less than 7 inches (180 mm) or three layers for pipe with wall thicknesses of 7 inches (180 mm) or greater. The layers shall not be separated by more than the thickness of one longitudinal member plus 1/4 inch (6 mm). The multiple layers shall be tied together to form a single rigid cage. All other specification requirements such as laps, welds and tolerances of placement in the wall of the pipe shall apply to this method of fabricating a line of reinforcement.

**1026.12 Longitudinal Reinforcement.** Each line of circumferential reinforcement shall be assembled into a cage which shall contain sufficient longitudinal bars or members, extending through the wall of the pipe, to maintain the reinforcement rigidly in shape and in correct position within the form. The exposure of the ends of longitudinal members, stirrups or spacers that have been used to position the cages during the placement of the concrete shall not be a cause for rejection.

**1026.13 Laps, Welds and Spacing.** If the splices are not welded, the reinforcement shall be lapped not less than 20 diameters for deformed bars and deformed cold worked wire and 40 diameters for plain bars and cold-drawn wire. In addition, where lapped cages of welded wire fabric are used without welding, the lap shall contain a longitudinal wire. If splices are welded and are not lapped to the minimum requirements above, pull tests of representative specimens shall develop at least 50 percent of the minimum specified strength of the steel and there shall be a minimum lap of 2 inches (50 mm). For butt-welded splices in bars or wire, pull tests of representative specimens shall develop at least 75 percent of the minimum specified strength of the steel. The spacing center to center of adjacent rings of circumferential reinforcement in a cage shall not exceed 4 inches (100 mm) for pipe up to and including pipe having a 4-inch (100 mm) wall thickness nor exceed the wall thickness for larger pipe and shall in no case exceed 6 inches (150 mm). The continuity of the circumferential reinforcing steel shall not be destroyed during the manufacture of the pipe.

**1026.14 Joints.** The joints shall be of such design and the ends of concrete pipe sections shall be so formed that when the sections are laid together they will make a continuous line of pipe with a smooth interior free from appreciable irregularities in the flowline compatible with the tolerances given in [Sec 1026.23.1](#). If specified, joints shall be Type A rubber gaskets conforming to the requirements of AASHTO M 198. The manufacturer shall make tests in accordance with Section 8 of AASHTO M 198 to demonstrate adequate performance and shall furnish a certification in triplicate that the physical and chemical properties of the gasket conform to the requirements of this specification.

## **Manufacture**

**1026.15 Placement of Concrete.** The transporting and placing of concrete shall be by methods that will prevent the segregation of the concrete material and the displacement of the reinforcement steel from its proper position in the form.

**1026.16 Curing.** Pipe shall be cured by any one of the following methods or by any other method or combination of methods approved by the engineer, that will give satisfactory

results. The pipe shall be cured for a sufficient length of time so that the concrete will develop the specified compressive strength at 28 days or less.

**1026.16.1 Steam Curing.** Pipe may be placed in a curing chamber, free from outside drafts and cured in a moist atmosphere maintained by the injection of steam for such time and at such temperature as may be needed to enable the pipe to meet the strength requirements. The curing chamber shall be so constructed as to allow full circulation of steam around the entire pipe.

**1026.16.2 Water Curing.** Concrete pipe may be water-cured by covering with water saturated material or by a system of perforated pipes, mechanical sprinklers, porous hose or by any other approved method that will keep the pipe moist during the specified curing period.

**1026.16.3** The manufacturer has the option to combine the methods described in [Sec 1026.16.1](#) and [1026.16.2](#) as long as the required concrete compressive strength is attained.

**1026.16.4 Curing Membrane.** A curing membrane conforming to the requirements of [Sec 1055](#) may be applied and shall be left intact until the strength requirements are met. The concrete at the time of application shall be within 10 degrees F (6 C) of the atmospheric temperature. All surfaces shall be kept moist prior to the application of the compound and shall be damp when the compound is applied.

**1026.17 Lift Holes.** If agreed upon by the engineer and the manufacturer, not more than two holes may be cast or drilled in the wall of each piece of pipe for the purpose of handling at the construction site. The holes shall not be larger than 2 1/2 inches (63 mm) in diameter and shall be carefully cast or drilled in a manner so that it is not necessary to cut, bend or otherwise weaken the circumferential steel in the inner cage in pipe having two lines of reinforcement or any of the circumferential steel in pipe having one line of reinforcement. Lift holes will be permitted for rubber gasketed pipe only with the written approval of the engineer.

### **Physical Test Requirements**

**1026.18 Test Specimens.** The specified number of pipe required for tests shall be furnished without charge by the manufacturer, selected at random by the engineer and shall be pipe that would not otherwise be rejected under these specifications. The selection will be made at the point or points designated by the engineer.

### **1026.19 Number and Type of Tests Required for Various Delivery Schedules.**

**1026.19.1 Preliminary Test for Extended Delivery Schedules.** When it is required to make shipments at intervals over extended periods of time, the engineer will make such tests, preliminary to delivery of pipe, as are required by the type of basis of acceptance specified in [Sec 1026.3](#), of not more than three sections of pipe covering each size.

**1026.19.2 Additional Tests for Extended Delivery Schedules.** After the preliminary tests specified in [Sec 1026.19.1](#), the engineer will make additional tests as considered necessary, provided that the total number of pipe tested, including preliminary tests, shall not exceed one percent of the pipe delivered.

**1026.19.3 Tests for Occasional Orders.** For occasional orders, the engineer will, as considered necessary, test a number of pipe not to exceed 2 percent of an order and not to exceed five pieces of any one size.

#### **1026.20 External Load Crushing Strength Test Requirements.**

**1026.20.1** The load to produce a 0.01-inch (0.3 mm) crack or the ultimate load, as determined by the three-edge bearing method described in AASHTO T 280, shall be not less than that specified in Tables I to V for each respective class of pipe. Pipe that have been tested only to the formation of a 0.01-inch (0.3 mm) crack and that meet the 0.01-inch (0.3 mm) test load requirements will be accepted for use.

**1026.20.2 Retests of Pipe Not Meeting the External Load Crushing Strength Test Requirements.** Pipe will be considered as meeting the strength test requirements when all test specimens conform to the test requirements. Should any of the test specimens fail to meet the test requirements, the manufacturer will be allowed a retest on two additional specimens for each specimen that failed and the pipe will be acceptable only if all of the retest specimens meet the strength requirements.

#### **1026.21 Concrete Test Requirements.**

**1026.21.1 Compression Tests.** Compression tests for satisfying the design concrete strength may be made on either standard rodded concrete cylinders or cylinders compacted and cured in like manner as the pipe or on cores drilled from the wall of the pipe. If cylinders are tested, they shall be tested in accordance with AASHTO T 22. The average compressive strength of all cylinders tested shall be equal to or greater than the design strength. If cores are cut from the wall of the pipe and tested, they shall be cut and tested in accordance with AASHTO T 280. The compressive strength of each core tested shall be equal to or greater than the design strength of the concrete. If a core does not meet the required strength, another core from the same pipe may be tested. If this core does not meet the required strength, that pipe will be rejected. Additional tests shall be made on other pipe to determine the acceptability of the lot. If the cores cut from a section of pipe meet the strength test requirement, the core-holes shall be plugged and sealed by the manufacturer in a manner such that the pipe section will meet all of the test requirements of these specifications. Pipe sections so sealed shall be considered as satisfactory for use.

**1026.21.2 Absorption Test Requirements of Concrete.** The absorption of a sample from the wall of the pipe, as determined in accordance with AASHTO T 280, shall not exceed 9 percent of the dry weight (mass). Each sample shall be a piece broken from the wall or a core drilled from the wall, have a minimum area of 9 square inches (580 mm<sup>2</sup>) as measured on one surface of the wall, have a thickness equal to the wall and be free of visible cracks. If the initial absorption specimen from a pipe fails to conform to these specifications, an absorption test shall be made on another specimen from the same pipe and the results of the retest shall be substituted for the original test results.

**1026.21.3 Retest of Pipe Not Meeting the Concrete Test Requirements.** If not more than 20 percent of the concrete test specimens fail to pass the requirements of the specification, the manufacturer may cull stock and may eliminate whatever quantity of pipe desired and shall so mark those pipe that they will not be shipped. The required tests shall be made on the remainder of the order and the pipe will be accepted if they conform to the test requirements.

**1026.22 Test Equipment.** Each manufacturer furnishing pipe under these specifications shall furnish all facilities and personnel necessary to carry out the tests described in AASHTO T 280.

#### **1026.23 Permissible Variations in Dimensions.**



**1026.23.1** Permissible variations in internal diameter are as shown in Table VI. The wall thickness shall not be less than that shown in the design by more than 5 percent or 3/16 inch (5 mm), whichever is greater. A wall thickness more than that required in the design shall not be a cause for rejection. Pipe having localized variations in wall thickness exceeding those specified above will be accepted if the three-edge bearing strength and minimum steel cover requirements are met.

**1026.23.2 Permissible Variations in the Position of the Reinforcement.** The maximum variation in the position of the reinforcement shall be 10 percent of the wall thickness or 1/2 inch (13 mm), whichever is greater. Pipe having variations in the position of the reinforcement exceeding those specified above will be accepted if the three-edge bearing strength requirements obtained on a representative specimen are met. In no case, however, shall the cover over the reinforcement be less than 1/2 inch (13 mm). These tolerances or cover requirements do not apply to mating surfaces of the joint.

**1026.23.3** Reinforcement will be considered as meeting the design requirements if the area, computed on the basis of nominal area of the wire or bars used, equals or exceeds the requirements of [Sec 1026.9](#) or [1026.10](#). Actual area of the reinforcement used may vary from the nominal area according to permissible variations of the specifications for the reinforcement. If inner cage and outer cage reinforcement is used, the inner cage design area may vary to the lower limit of 85 percent of the elliptical design area and the outer cage design area may vary to the lower limit of 51 percent of the elliptical design area provided that the total design area of the inner cage plus the outer cage shall not vary beyond the lower limit of 140 percent of the elliptical design area.

**1026.23.4** Variations in the laying length of two opposite sides of pipe shall be not more than 1/4 inch for all sizes through 24-inch (600 mm) internal diameter and not more than 1/8 inch per foot (10 mm/m) of internal diameter for all sizes larger with a maximum of 5/8 inch (16 mm) in any length of pipe through 84-inch (2100 mm) internal diameter and a maximum of 3/4 inch (19 mm) for 90-inch (2250 mm) diameter or larger, except where beveled end pipe for laying on curves is specified.

**1026.23.5** The underrun in length of a section of pipe shall be not more than 1/8 inch per foot (10 mm/m) with a maximum of 1/2 inch (13 mm) in any length of pipe.

**1026.24 Finish.** Pipe shall be substantially free of fractures, large or deep cracks and surface roughness. The ends of the pipe shall be normal to the walls and centerline of the pipe, within the limits of variations given in [Sec 1026.23.4](#) and [1026.23.5](#).

**1026.25 Marking.** The following information shall be clearly marked on the inside of each section of pipe by indenting on the pipe section or by painting thereon with waterproof paint:

- (a) The pipe class and type of wall.
- (b) The date of manufacture.
- (c) The name or trade-mark of the manufacturer.

(d) One end of each section of pipe with elliptical reinforcement shall be clearly marked, during the process of manufacturing or immediately thereafter, on the inside and the outside of opposite walls along the minor axis of the elliptical reinforcement with the word "Top" or "Bottom" to designate the proper position when laid.

**1026.26 Inspection.** The quality of material, the process of manufacture and the finished pipe shall be subject to inspection and approval by the engineer.

**1026.27 Rejection.** Pipe shall be subject to rejection for failure to conform to any of the specification requirements. Individual sections of pipe may be rejected because of any of the following:

- (a) Fractures or cracks passing through the wall except for a single end crack that does not exceed the depth of the joint.

- (b) Defects that indicate imperfect proportioning, mixing or molding.

- (c) Surface defects indicating honeycombed or open texture.

- (d) Damaged or unsatisfactorily manufactured ends, if such would prevent making a satisfactory joint.

- (e) Any continuous crack having a surface width of 0.01 inch (0.3 mm) or more and extending for a length of 12 inches (300 mm) or more, regardless of position in the wall of the pipe.

**1026.28 Repairs.** Pipe may be repaired, if necessary, because of occasional imperfections in manufacture or accidental injury during handling and will be acceptable if, in the judgment of the engineer, the repairs are sound and properly finished and cured and the repaired pipe conforms to the requirements of these specifications.

**(Blank)**



TABLE I									
Design Requirements for Class I Reinforced Concrete Pipe <sup>a</sup>									
ENGLISH									
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.									
The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.									
D-Load to produce a 0.01-in. crack ..... 800									
D-Load to produce the ultimate load <sup>b</sup> ..... 1200									
Internal Diameter of Pipe, in.	Reinforcement, sq. in. per linear foot of pipe wall <sup>1</sup>								
	Wall A				Wall B				
	Concrete Strength, 4000 psi				Concrete Strength, 4000 psi				
	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	
		Inner Cage	Outer Cage			Inner Cage	Outer Cage		
60	5	0.25	0.15	0.28	6	0.21	0.13	0.23	
66	5 1/2	0.30	0.18	0.33	6 1/2	0.25	0.15	0.28	
72	6	0.35	0.21	0.39	7	0.29	0.17	0.32	
78	6 1/2	0.40	0.24	0.44	7 1/2	0.32	0.19	0.36	
84	7	0.45	0.27	0.50	8	0.37	0.22	0.41	
90	7 1/2	0.49	0.29	0.54	8 1/2	0.41	0.25	0.46	
96	8	0.54	0.32	0.60	9	0.46	0.28	0.51	
	Concrete Strength, 5000 psi								
102	8 1/2	0.63	0.38	Inner Circular 0.25 Plus Elliptical 0.38	9 1/2	0.54	0.32	Inner Circular 0.22 Plus Elliptical 0.32	
108	9	0.68	0.41	Inner Circular 0.27 Plus Elliptical 0.41	10	0.61	0.37	Inner Circular 0.24 Plus Elliptical 0.37	

METRIC									
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.									
The strength test requirements in newtons per linear meter of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in newtons per linear meter per millimeter of diameter) to produce a 0.3-mm crack, or the D-loads to produce the 0.3-mm crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in millimeters.									
D-Load to produce a 0.3-mm crack ..... 40.0									
D-Load to produce the ultimate load <sup>b</sup> ..... 60.0									
Internal Diameter of Pipe, mm	Reinforcement, cm <sup>2</sup> / linear m of pipe wall <sup>i</sup>								
	Wall A				Wall B				
	Concrete Strength, 27.6Pa				Concrete Strength, 27.6 MPa				
	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	
		Inner Cage	Outer Cage			Inner Cage	Outer Cage		
1500	125	5.3	3.2	5.9	150	4.4	2.6	4.9	
1650	138	6.4	3.8	7.0	163	5.3	3.2	5.9	
1800	150	7.4	4.4	8.3	175	6.1	3.7	6.8	
1950	163	8.5	5.1	9.3	188	6.8	4.1	7.6	
2100	175	9.5	5.7	10.6	200	7.8	4.7	8.7	
2250	188	10.4	6.2	11.4	213	8.7	5.2	9.7	
2400	200	11.4	6.8	12.7	225	9.7	5.8	10.8	
	Concrete Strength, 34.5 MPa								
2250	213	13.3	8.0	Inner Circular 5.3 Plus Elliptical 8.0	238	11.4	6.8	Inner Circular 4.6 Plus Elliptical 6.8	
2700	225	14.4	8.6	Inner Circular 5.8 Plus Elliptical 8.6	250	12.9	7.7	Inner Circular 5.2 Plus Elliptical 7.7	

See footnotes under Table V.

TABLE II												
Design Requirements for Class II Reinforced Concrete Pipe <sup>a</sup>												
ENGLISH												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.												
D-Load to produce a 0.01-in. crack .....1000												
D-Load to produce the ultimate load <sup>b</sup> .....1500												
Internal Diameter of Pipe, in.	Reinforcement, sq. in. per linear foot of pipe wall <sup>i</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 4000 psi				Concrete Strength, 4000 psi				Concrete Strength, 4000 psi			
	Wall Thick- ness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforce- ment <sup>d</sup>	Wall Thick- ness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforce- ment <sup>d</sup>	Wall Thick- ness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforce- ment <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
12	1 3/4	0.07 <sup>e</sup>	....	....	2	0.07 <sup>e</sup>	....	....	2 3/4	0.07 <sup>e</sup>	....	....
15	1 7/8	0.07 <sup>e</sup>	....	....	2 1/4	0.07 <sup>e</sup>	....	....	3	0.07 <sup>e</sup>	....	....
18	2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	2 1/2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	3 1/4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
21	2 1/4	0.12	....	0.10	2 3/4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	3 1/2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
24	2 1/2	0.13	....	0.11	3	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	3 3/4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
27	2 5/8	0.15	....	0.13	3 1/4	0.13	....	0.11	4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
30	2 3/4	0.15	....	0.14	3 1/2	0.14	....	0.12	4 1/4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
33	2 7/8	0.16	....	0.15	3 3/4	0.15	....	0.13	4 1/2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
36	3	0.14	0.08	0.15	4 <sup>g</sup>	0.12	0.07	0.13	4 3/4	0.07	0.07	0.08
42	3 1/2	0.16	0.10	0.18	4 1/2	0.15	0.09	0.17	5 1/4	0.10	0.07	0.11

48	4	0.21	0.13	0.23	5	0.18	0.11	0.20	5 3/4	0.14	0.08	0.15
54	4 1/2	0.25	0.15	0.28	5 1/2	0.22	0.13	0.24	6 1/4	0.17	0.10	0.19
60	5	0.30	0.18	0.33	6	0.25	0.15	0.28	6 3/4	0.22	0.13	0.24
66	5 1/2	0.35	0.21	0.39	6 1/2	0.31	0.19	0.34	7 1/4	0.25	0.15	0.28
72	6	0.41	0.25	0.45	7	0.35	0.21	0.39	7 3/4	0.30	0.18	0.33
78	6 1/2	0.46	0.28	0.51	7 1/2	0.40	0.24	0.44	8 1/4	0.35	0.21	0.39
84	7	0.51	0.31	0.57	8	0.46	0.28	0.51	8 3/4	0.41	0.25	0.46
90	7 1/2	0.57	0.34	0.63	8 1/2	0.51	0.31	0.57	9 1/4	0.48	0.29	0.53
96	8	0.62	0.37	0.69	9	0.57	0.34	0.63	9 3/4	0.55	0.33	0.61
	<b>Concrete Strength, 5000 psi</b>				<b>Concrete Strength, 5000 psi</b>				<b>Concrete Strength, 5000 psi</b>			
102	8 1/2	0.76	0.46	Inner Circular 0.30 Plus Elliptical0.46	9 1/2	0.68	0.41	Inner Circular 0.27 Plus Elliptical0.41	10 1/4	0.62	0.37	Inner Circular 0.25 Plus Elliptical 0.37
108	9	0.85	0.51	Inner Circular 0.34 Plus Elliptical0.51	10	0.76	0.46	Inner Circular 0.30 Plus Elliptical0.46	10 3/4	0.70	0.42	Inner Circular 0.28 Plus Elliptical 0.42



METRIC												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in newtons per linear meter of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in newtons per linear meter per millimeter of diameter) to produce a 0.3-mm crack, or the D-loads to produce the 0.3-mm crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in millimeters.												
D-Load to produce a 0.3-mm crack ..... 50.0												
D-Load to produce the ultimate load <sup>B</sup> ..... 75.0												
Internal Diameter of Pipe, mm	Reinforcement, cm <sup>2</sup> /linear m of pipe wall <sup>i</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 27.6 MPa				Concrete Strength, 27.6 MPa				Concrete Strength, 27.6 MPa			
	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
300	44	1.5 <sup>e</sup>	....	....	50	1.5 <sup>e</sup>	....	....	69	1.5 <sup>e</sup>	....	....
375	47	1.5 <sup>e</sup>	....	....	57	1.5 <sup>e</sup>	....	....	75	1.5 <sup>e</sup>	....	....
450	50	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	63	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	82	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
525	57	2.5	....	2.1	69	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	88	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
600	63	2.8	....	2.3	75	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	94	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
675	66	3.2	....	2.8	82	2.8	....	2.3	100	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
750	69	3.2	....	3.0	88	3.0	....	2.5	106	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
825	72	3.4	....	3.2	94	3.2	....	2.8	113	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
900	75	3.0	1.8	3.2	100 <sup>g</sup>	2.5	1.5	2.8	119 <sup>g</sup>	1.5	1.5	7.1
1050	88	3.4	2.0	3.8	113	3.2	1.9	3.6	132	2.1	1.5	2.3
1200	100	4.5	2.7	4.9	125	3.8	2.3	4.2	144	3	1.8	3.2
1350	113	5.3	3.2	5.9	138	4.7	2.8	5.1	157	3.6	2.2	4.0

1500	125	6.4	3.8	7.0	150	5.3	3.2	5.9	169	4.7	2.8	5.1
1650	138	7.4	4.4	8.3	163	6.6	4.0	7.2	182	5.3	3.2	5.9
1800	150	8.7	5.2	9.5	175	7.4	4.4	8.3	194	6.4	3.8	7.0
1950	163	9.7	5.8	10.8	188	8.5	5.1	9.3	207	7.4	4.4	8.3
2100	175	10.8	6.5	12.1	200	9.7	5.8	10.8	219	8.7	5.2	9.7
2250	188	12.1	7.3	13.3	213	10.8	6.5	12.1	232	10.2	6.1	11.2
2400	200	13.1	7.9	14.6	225	12.1	7.3	13.3	244	11.6	7.0	12.9
	<b>Concrete Strength, 34.5 MPa</b>				<b>Concrete Strength, 34.5 MPa</b>				<b>Concrete Strength, 34.5 MPa</b>			
2550	213	0.76	9.7	Inner Circular 6.4 Plus Elliptical 9.7	238	14.4	8.6	Inner Circular 5.8 Plus Elliptical 8.6	257	13.1	7.9	Inner Circular 5.2 Plus Elliptical 7.9
2700	225	0.85	10.8	Inner Circular 7.2 Plus Elliptical 10.8	250	16.1	9.7	Inner Circular 6.4 Plus Elliptical 9.7	269	14.8	8.9	Inner Circular 5.9 Plus Elliptical 8.9

See footnotes under Table V.

TABLE III												
Design Requirements for Class III Reinforced Concrete Pipe <sup>a</sup>												
ENGLISH												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.												
D-Load to produce a 0.01-in. crack ..... 1350												
D-Load to produce the ultimate load <sup>b</sup> ..... 2000												
Internal Diameter of Pipe, in.	Reinforcement, sq. in. per linear foot of pipe wall <sup>f</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 4000 psi				Concrete Strength, 4000 psi				Concrete Strength, 4000 psi			
	Wall Thick- ness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforce- ment <sup>d</sup>	Wall Thick- ness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforce- ment <sup>d</sup>	Wall Thick- ness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforce- ment <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
12	1 3/4	0.07 <sup>e</sup>	....	....	2	0.07 <sup>e</sup>	....	....	2 3/4	0.07 <sup>e</sup>	....	....
15	1 7/8	0.07 <sup>e</sup>	....	....	2 1/4	0.07 <sup>e</sup>	....	....	3	0.07 <sup>e</sup>	....	....
18	2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	2 1/2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	3 1/4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
21	2 1/4	0.14	....	0.11	2 3/4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	3 1/2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
24	2 1/2	0.17	....	0.14	3	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	3 3/4	0.07	....	0.07 <sup>e</sup>
27	2 5/8	0.18	....	0.16	3 1/4	0.16	....	0.14	4	0.08	....	0.07 <sup>e</sup>
30	2 3/4	0.19	....	0.18	3 1/2	0.18	....	0.15	4 1/4	0.10	....	0.08
33	2 7/8	0.21	....	0.20	3 3/4	0.20	....	0.17	4 1/2	0.12	....	0.10
36	3	0.21	0.13	0.23	4	0.17	0.10	0.19	4 3/4 <sup>b</sup>	0.08	0.07	0.09
42	3 1/2	0.25	0.15	0.28	4 1/2	0.21	0.13	0.23	5 1/4	0.12	0.07	0.13

48	4	0.32	0.19	0.35	5	0.24	0.14	0.27	5 3/4	0.16	0.10	0.18
54	4 1/2	0.38	0.23	0.42	5 1/2	0.29	0.17	0.32	6 1/4	0.21	0.13	0.23
60	5	0.44	0.26	0.49	6	0.34	0.20	0.38	6 3/4	0.25	0.15	0.28
66	5 1/2	0.50	0.30	0.55	6 1/2	0.41	0.25	0.46	7 1/4	0.31	0.19	0.34
72	6	0.57	0.34	0.63	7	0.49	0.29	0.54	7 3/4	0.36	0.22	0.40
	Concrete Strength, 5000 psi											
78	6 1/2	0.64	0.38	0.71	7 1/2	0.57	0.34	0.63	8 1/4	0.42	0.25	0.47
84	7	0.72	0.43	0.80	8	0.64	0.38	0.71	8 3/4	0.50	0.30	0.56
					Concrete Strength, 5000 psi				Concrete Strength, 5000 psi			
90	7 1/2	0.81	0.49	0.90	8 1/2	0.69	0.41	0.77	9 1/4	0.59	0.35	0.66
96	8	0.93	0.56	1.03	9	0.76	0.46	0.84	9 3/4	0.70	0.42	Inner Circular 0.28 Plus Elliptical 0.42
102	8 1/2	1.03	0.62	Inner Circular 0.41 Plus Elliptical 0.62	9 1/2	0.90	0.54	Inner Circular 0.36 Plus Elliptical 0.54	10 1/4	0.83	0.50	Inner Circular 0.33 Plus Elliptical 0.50
108	9	1.22	0.73	Inner Circular 0.49 Plus Elliptical 0.73	10	1.08	0.65	Inner Circular 0.43 Plus Elliptical 0.65	10 3/4	0.99	0.59	Inner Circular 0.40 Plus Elliptical 0.59

METRIC												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in newtons per linear meter of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in newtons per linear meter per millimeter of diameter) to produce a 0.3-mm crack, or the D-loads to produce the 0.3-mm crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in millimeters.												
D-Load to produce a 0.3-mm crack .....65.0												
D-Load to produce the ultimate load <sup>b</sup> .....100.0												
Internal Diameter of Pipe, mm	Reinforcement, cm <sup>2</sup> /per linear m of pipe wall <sup>i</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 27.6 MPa				Concrete Strength, 27.6 MPa				Concrete Strength, 27.6 MPa			
	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
300	44	1.5 <sup>e</sup>	....	....	50	1.5 <sup>e</sup>	....	....	69	1.5 <sup>e</sup>	....	....
375	47	1.5 <sup>e</sup>	....	....	57	1.5 <sup>e</sup>	....	....	75	1.5 <sup>e</sup>	....	....
450	50	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	63	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	82	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
525	57	3.0	....	2.3	69	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	88	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
600	63	3.6	....	3.0	75	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	94	1.5	....	1.5 <sup>e</sup>
675	66	3.8	....	3.4	82	3.4	....	3.0	100	1.7	....	1.5 <sup>e</sup>
750	69	4.0	....	3.8	88	3.8	....	3.2	107	2.1	....	1.7
825	72	4.4	....	4.2	94	4.2	....	3.6	113	2.5	....	2.1
900	75	4.4	2.6	4.7	100 <sup>h</sup>	3.6	2.2	4.0	119 <sup>h</sup>	1.7	1.5	1.9
1050	88	5.3	3.2	5.9	113	4.4	2.6	4.9	132	2.5	1.5	2.8
1200	100	6.8	4.1	7.4	125	5.1	3.1	5.7	144	3.4	2.0	3.8
1350	113	8.0	4.8	8.9	138	6.1	3.7	6.8	157	4.4	2.6	4.9

1500	125	9.3	5.6	10.4	150	7.2	4.3	8.0	169	5.3	3.2	5.9
1650	138	10.6	6.4	11.6	163	9.1	5.5	9.7	182	6.6	4.0	7.2
1800	150	12.1	7.3	13.3	175	10.4	6.2	11.4	194	7.6	4.6	8.5
	Concrete Strength, 34.5 MPa											
1950	163	13.5	8.1	15.0	188	12.1	7.3	13.3	207	8.9	5.3	9.9
2100	175	15.2	9.1	16.9	200	13.5	8.1	15.0	219	10.6	6.4	11.9
					Concrete Strength, 34.5 MPa				Concrete Strength, 34.5 MPa			
2250	188	17.1	10.3	19.1	213	14.6	8.8	16.3	232	12.5	7.2	14.0
2400	200	19.7	11.8	21.8	225	16.1	9.7	17.8	244	14.8	8.9	Inner Circular 5.9 Plus Elliptical 8.9
2550	213	21.8	13.1	Inner Circular 8.7 Plus Elliptical 13.1	238	19.1	11.5	Inner Circular 7.6 Plus Elliptical 11.5	257	17.6	10.6	Inner Circular 7.0 Plus Elliptical 10.6
2700	225	25.8	15.5	Inner Circular 10.3 Plus Elliptical 15.5	250	22.9	13.7	Inner Circular 9.2 Plus Elliptical 13.7	269	21.0	12.6	Inner Circular 8.4 Plus Elliptical 12.6

See Footnotes under Table V.

TABLE IV												
Design Requirements for Class IV Reinforced Concrete Pipe <sup>a</sup>												
ENGLISH												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.												
D-Load to produce a 0.01-in. crack ..... 2000												
D-Load to produce the ultimate load <sup>b</sup> ..... 3000												
Internal Diameter of Pipe, in.	Reinforcement, sq. in. per linear foot of pipe wall <sup>1</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 5000 psi				Concrete Strength, 5000 psi				Concrete Strength, 5000 psi			
	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
12	1 3/4	0.15	....	....	2	0.07	....	....	2 3/4	0.07 <sup>1</sup>	....	....
15	1 7/8	0.16	....	....	2 1/4	0.10	....	....	3	0.07 <sup>1</sup>	....	....
18	2	0.17	....	0.15	2 1/2	0.14	....	0.11	3 1/4	0.07 <sup>1</sup>	....	0.07 <sup>1</sup>
21	2 1/4	0.23	....	0.21	2 3/4	0.20	....	0.17	3 1/2	0.07 <sup>1</sup>	....	0.07 <sup>1</sup>
24	2 1/2	0.29	....	0.27	3	0.27	....	0.23	3 3/4	0.07	0.07	0.08
27	2 5/8	0.33	....	0.31	3 1/4	0.31	....	0.25	4	0.08	0.07	0.09
30	2 3/4	0.38	....	0.35	3 1/2	0.35	....	0.28	4 1/4	0.09	0.07	0.10
33	<sup>a</sup>	....	....	....	3 3/4	0.27	0.16	0.30	4 1/2	0.11	0.07	0.12
36	<sup>a</sup>	....	....	...	4	0.30	0.18	0.33	4 3/4	0.14	0.08	0.15

42	a	....	....	....	4 1/2	0.35	0.21	0.39	5 1/4	0.20	0.12	0.22
48	a	....	....	....	5	0.42	0.25	0.47	5 3/4	0.26	0.16	0.29
54	a	....	....	....	5 1/2	0.50	0.30	0.55	6 1/4	0.34	0.20	0.38
60	a	....	....	....	Concrete Strength, 5000 psi				6 3/4	0.41	0.25	0.46
					6	0.59	0.35	0.66				
66	a	....	....	....	6 1/2	0.69	0.41	0.77	7 1/4	0.51	0.31	0.57
									Concrete Strength, 5000 psi			
72	a	....	....	....	7	0.79	0.47	0.88	7 3/4	0.61	0.37	0.68
78	a	....	....	....	a	....	....	....	8 1/4	0.71	0.43	0.79
84	a	....	....	....	a	....	....	....	8 3/4	0.85	0.51	0.94
90	a	....	....	....	a	....	....	....	a	....	....	....
96	a	....	....	....	a	....	....	....	a	....	....	....
102	a	....	....	....	a	....	....	....	a	....	....	....
108	a	....	....	....	a	....	....	....	a	....	....	....



METRIC												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in newtons per linear meter of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in newtons per linear meter per millimeter of diameter) to produce a 0.3-mm crack, or the D-loads to produce the 0.3-mm crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in millimeters.												
D-Load to produce a 0.3-mm crack ..... 100.0												
D-Load to produce the ultimate load <sup>b</sup> ..... 150.0												
Internal Diameter of Pipe, mm	Reinforcement, cm <sup>2</sup> /linear m of pipe wall <sup>i</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 34.5 MPa				Concrete Strength, 34.5 MPa				Concrete Strength, 34.5 MPa			
	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
300	44	0.15	....	....	50	1.5	....	....	69	1.5 <sup>f</sup>	....	....
375	47	0.16	....	....	57	2.1	....	....	75	1.5 <sup>f</sup>	....	....
450	50	0.17	....	3.2	63	3.0	....	2.3	82	1.5 <sup>f</sup>	....	1.5 <sup>f</sup>
525	57	0.23	....	4.4	69	4.2	....	3.6	88	1.5 <sup>f</sup>	....	1.5 <sup>f</sup>
600	63	0.29	....	5.7	75	5.7	....	4.9	94	1.5	1.5	1.7
675	66	0.33	....	6.6	82	6.3	....	5.3	100	1.7	1.5	1.9
750	69	0.38	....	7.4	88	7.4	....	5.9	107	1.9	1.5	2.1
825	<sup>a</sup>	....	....	....	94	5.7	3.4	6.3	113	2.3	1.5	2.5
900	<sup>a</sup>	....	....	...	100	6.3	3.8	7.0	119	3.0	1.8	3.2
1050	<sup>a</sup>	....	....	....	113	7.4	4.4	8.3	132	4.2	2.5	4.7

1200	a	....	....	....	125	8.9	5.3	9.9	144	5.5	3.3	6.1
1350	a	....	....	....	138	10.6	6.4	11.6	157	7.2	4.3	8
1500	a	....	....	....	Concrete Strength, 34.5 MPa				169	8.7	5.2	9.7
					150	12.5	7.5	14.0				
1650	a	....	....	....	163	14.6	8.8	16.3	182	10.8	6.5	12.1
									Concrete Strength, 34.5 MPa			
1800	a	....	....	....	175	16.7	10.0	18.6	194	12.9	7.7	14.4
1950	a	....	....	....	A	....	....	....	207	15.0	9.0	16.7
2100	a	....	....	....	A	....	....	....	219	18.0	10.8	19.9
2250	a	....	....	....	A	....	....	....	a	....	....	....
2400	a	....	....	....	A	....	....	....	a	....	....	....
2550	a	....	....	....	A	....	....	....	a	....	....	....
2700	a	....	....	....	A	....	....	....	a	....	....	....

See Footnotes under Table V.

TABLE V												
Design Requirements for Class V Reinforced Concrete Pipe <sup>a</sup>												
ENGLISH												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.												
D-Load to produce a 0.01-in. crack ..... 3000												
D-Load to produce the ultimate load <sup>b</sup> ..... 3750												
Internal Diameter of Pipe, in.	Reinforcement, sq. in. per linear foot of pipe wall <sup>1</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 6000 psi				Concrete Strength, 6000 psi				Concrete Strength, 6000 psi			
	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
12	<sup>a</sup>	....	....	....	2	0.10	....	....	2 3/4	0.07 <sup>1</sup>	....	....
15	<sup>a</sup>	....	....	....	2 1/4	0.14	....	....	3	0.07 <sup>1</sup>	....	....
18	<sup>a</sup>	....	....	....	2 1/2	0.19	....	0.16	3 1/4	0.10	....	....
21	<sup>a</sup>	....	....	....	2 3/4	0.24	....	0.21	3 1/2	0.10	....	....
24	<sup>a</sup>	....	....	....	3	0.30	....	0.24	3 3/4	0.12	0.07	0.13
27	<sup>a</sup>	....	....	....	3 1/4	0.38	0.23	0.42	4	0.14	0.08	0.16
30	<sup>a</sup>	....	....	....	3 1/2	0.41	0.25	0.46	4 1/4	0.18	0.11	0.20
33	<sup>a</sup>	....	....	....	3 3/4	0.46	0.28	0.51	4 1/2	0.23	0.14	0.25
36	<sup>a</sup>	....	....	....	4	0.50	0.30	0.56	4 3/4	0.27	0.16	0.30

42	a	....	....	....	4 1/2	0.60	0.36	0.67	5 1/4	0.36	0.22	0.40
48	a	....	....	....	5	0.73	0.44	0.81	5 3/4	0.47	0.28	0.52
54	a	....	....	....	a	....	....	....	6 1/4	0.58	0.35	0.64
60	a	....	....	....	a	....	....	....	6 3/4	0.70	0.42	0.78
66	a	....	....	....	a	....	....	....	7 1/4	0.74	0.50	0.93
72	a	....	....	....	a	....	....	....	7 3/4	0.99	0.59	1.10
78	a	....	....	....	a	....	....	....	a	....	....	....
84	a	....	....	....	a	....	....	....	a	....	....	....
90	a	....	....	....	a	....	....	....	a	....	....	....
96	a	....	....	....	a	....	....	....	a	....	....	....
102	a	....	....	....	a	....	....	....	a	....	....	....
108	a	....	....	....	a	....	....	....	a	....	....	....

METRIC												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in newtons per linear meter of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in newtons per linear meter per millimeter of diameter) to produce a 0.3-mm crack, or the D-loads to produce the 0.3-mm crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in millimeters.												
D-Load to produce a 0.03-mm crack ..... 140.0												
D-Load to produce the ultimate load <sup>b</sup> ..... 175.0												
Internal Diameter of Pipe, mm	Reinforcement, cm <sup>2</sup> /linear m of pipe wall <sup>i</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 41.4 MPa				Concrete Strength, 41.4 MPa				Concrete Strength, 41.4 MPa			
	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
300	a	....	....	....	50	2.1	....	....	69	1.5 <sup>i</sup>	....	....
375	a	....	....	....	57	3.0	....	....	75	1.5 <sup>i</sup>	....	....
450	a	....	....	....	63	4.0	....	3.4	82	2.1	....	....
525	a	....	....	....	69	5.1	....	4.4	88	2.1	....	....
600	a	....	....	....	75	6.4	....	5.1	94	2.5	1.5	2.8
675	a	....	....	....	82	8.0	4.8	8.9	100	3.0	1.8	3.4
750	a	....	....	....	88	8.7	5.2	9.7	107	3.8	2.3	4.2
825	a	....	....	....	94	9.7	5.8	10.8	113	4.9	2.9	5.3
900	a	....	....	....	100	10.6	6.4	11.9	119	5.7	3.4	6.3
1050	a	....	....	....	113	12.7	7.6	14.2	132	7.6	4.6	8.5
1200	a	....	....	....	125	15.5	9.3	17.1	144	9.9	5.9	11

1350	a	....	....	....	a	....	....	....	157	12.3	7.4	13.5
1500	a	....	....	....	a	....	....	....	169	14.8	8.9	16.5
1650	a	....	....	....	a	....	....	....	182	17.8	10.7	19.7
1800	a	....	....	....	a	....	....	....	194	21.0	12.6	23.3
1950	a	....	....	....	a	....	....	....	a	....	....	....
2100	a	....	....	....	a	....	....	....	a	....	....	....
2250	a	....	....	....	a	....	....	....	a	....	....	....
2400	a	....	....	....	a	....	....	....	a	....	....	....
2550	a	....	....	....	a	....	....	....	a	....	....	....
2700	a	....	....	....	a	....	....	....	a	....	....	....

- <sup>a</sup> For modified or special designs, see [Sec 1026.10](#) or with the permission of the engineer utilize the provisions for AASHTO M 242. Steel areas may be interpolated between those shown for variations in diameter, loading or wall thickness. Pipe over 96 inches (2400 mm) in diameter shall have two circular cages or an inner circular plus one elliptical cage.
- <sup>b</sup> Three-edge-bearing test to ultimate load is not required for any class of pipe 60 inches (1500 mm) or less in diameter provided all other requirements of this specification are met.
- <sup>c</sup> As an alternate to design requiring both inner and outer circular cages, the reinforcement may be positioned and proportioned in either of the following manners:
- An inner circular cage plus an elliptical cage such that the area shall not be less than that specified for the outer cage in the table and the total area of the inner circular cage plus the elliptical cage shall not be less than that specified for the inner cage in the table.
  - An inner and outer cage plus quadrant mats in accordance with Figure 1 of AASHTO M 170, or
  - An inner and outer cage plus an elliptical cage in accordance with Figure 2 of AASHTO M 170.
- <sup>d</sup> Elliptical and quadrant steel must be held in place by means of holding rods, chairs or other positive means throughout the entire casting operation.
- <sup>e</sup> For these classes and sizes, the minimum practical steel reinforcement is specified. The actual ultimate strength is greater than the minimum strength specified for non reinforced pipe of equivalent diameters in AASHTO M 86.
- <sup>f</sup> For these classes and sizes, the minimum practical steel reinforcement is specified.
- <sup>g</sup> As an alternative, single cage reinforcement may be used. The reinforcement area is square inches per linear foot (square centimeters per linear meter) shall be 0.20 (4.2) for wall B and 0.16 (3.4) for wall C.
- <sup>h</sup> As an alternative, single cage reinforcement may be used. The reinforcement area is square inches per linear foot (square centimeters per linear meter) shall be .30 (6.4) for wall B and 0.20 (4.2) for wall C.
- <sup>i</sup> Reinforcement of pipe wall may be either that specified under Circular Reinforcement or as specified under Elliptical Reinforcement.





<b>TABLE VI</b>		
<b>Permissible Variations in Internal Diameter</b>		
<b>Diameter of Pipe, Inches (mm)</b>	<b>Min., Inches (mm)</b>	<b>Max., Inches (mm)</b>
12 (300)	11.875 (300)	12.125 (310)
15 (375)	14.75 (375)	15.25 (390)
18 (450)	17.75 (450)	18.25 (465)
21 (525)	20.625 (525)	21.375 (545)
24 (600)	23.625 (600)	24.375 (620)
27 (675)	26.625 (675)	27.375 (695)
30 (750)	29.625 (750)	30.375 (775)
33 (825)	32.625 (825)	33.375 (850)
36 (900)	35.625 (900)	36.375 (925)
42 (1050)	41.625 (1050)	42.375 (1080)
48 (1200)	47.5 (1200)	48.5 (1230)
54 (1350)	53.5 (1350)	54.5 (1385)
60 (1500)	59.375 (1500)	60.625 (1540)
66 (1650)	65.375 (1650)	66.625 (1695)
72 (1800)	71.25 (1800)	72.75 (1850)
78 (1950)	77.25 (1950)	78.75 (2000)
84 (2100)	83.125 (2100)	84.875 (2155)
90 (2250)	89.125 (2250)	90.875 (2310)
96 (2400)	95.0 (2400)	97.0 (2465)
102 (2550)	101.0 (2550)	103.0 (2620)
108 (2700)	106.875 (2700)	109.125 (2770)
114 (2850)	112.875 (2850)	115.125 (2925)
120 (3000)	118.75 (3000)	121.25 (3080)
126 (3150)	124.75 (3150)	127.25 (3235)
132 (3300)	130.625 (3300)	133.375 (3390)
138 (3400)	136.625 (3450)	139.375 (3540)
144 (3600)	142.5 (3600)	145.5 (3695)

## SECTION 1030

### VITRIFIED CLAY SEWER AND CULVERT PIPE

**1030.1 Vitrified Clay Sewer and Culvert Pipe.** These specifications cover two classes of vitrified clay pipe: Standard Strength Clay Pipe for conveyance of sewage, industrial wastes and storm waters, and Extra Strength Clay Pipe for constructing culverts or where high strength pipe is desired. Vitrified clay pipe of these classes shall conform to the requirements of AASHTO M 65. Pipe may be of bell and spigot construction or plain-end.

**1030.2 Joints.** Pipe shall be provided with compression joints conforming to the requirements of ASTM C 425. The contractor shall furnish a manufacturer's certification in triplicate showing typical chemical resistance results of the joint material and physical test results representative of the joint performance and certifying that the joints conform to all the requirements specified.

## **SECTION 1031**

### **CLAY DRAIN TILE**

**1031.1 Clay Drain Tile.** This tile shall conform to the requirements of AASHTO M 179, except that paragraphs 6.3, 6.5 and 7.4 shall not apply. Unless otherwise specified in the contract, only Type II, Extra-Quality or Type III, Heavy-Duty Drain Tile, shall be furnished.

## SECTION 1032

### PRECAST CONCRETE FLARED END SECTIONS

**1032.1 Scope.** These specifications cover reinforced precast concrete flared end sections for use at inlets and outlets of rigid pipe culverts.

**1032.2 Basis of Acceptance.** Acceptability of end sections for all diameters shall be determined by the results of such material tests as are required in [Sec 1026.5](#), [1026.6](#) and [1026.7](#); by crushing tests on concrete cores or cured concrete cylinders; and by inspection of the finished end sections, including quantity and placement of reinforcement, to determine the conformance with the design and the freedom from defects.

**1032.2.1** Flared end sections shall meet all applicable requirements of [Sec 1026](#) for Class II pipe or higher classes of pipe.

## SECTION 1033

### PRECAST REINFORCED CONCRETE MANHOLE AND DROP INLET SECTIONS

**1033.1 Scope.** These specifications cover precast reinforced concrete manhole and drop inlet sections and appurtenances such as grade rings, tops and special sections.

**1033.2 Basis of Acceptance.** Unless otherwise specified in the contract, acceptance of precast reinforced concrete manhole and drop inlet sections will be on the basis of tests of material and inspection of the completed product. Acceptability of all types of sections covered by these specifications will be determined by the material tests required in [Sec 1033.3](#); by crushing tests on concrete cores or cured concrete cylinders; by absorption tests on selected samples of concrete from the wall of the sections; and by inspections of the finished sections, including quantity and placement of reinforcement, to determine conformance with these specifications and their freedom from defect. If Class B or B-1 concrete is used, compressive tests and absorption test specimens will not be required.

#### **1033.3 Material.**

**1033.3.1 Cement.** Cement shall conform to the requirements of [Sec 1019](#).

**1033.3.2 Fly Ash.** Fly ash shall comply with the requirements of [Sec 1018](#).

**1033.3.3 Aggregates.** Fine and coarse aggregate shall conform to the requirements of [Sec 1005](#), except that requirements for gradation and percent passing the No. 200 (75  $\mu$ m) sieve shall not apply.

**1033.3.4 Steel Reinforcement.** Reinforcement may consist of wire conforming to AASHTO M 32 or AASHTO M 225; or of wire fabric conforming to AASHTO M 55 or AASHTO M 221; or of bars conforming to AASHTO M 31.

**1033.3.5 Mixture.** The aggregates shall be sized, graded, proportioned and thoroughly mixed in a batch mixer with such proportions of cement and water, as will produce a homogeneous concrete mixture of such quality that the manhole and drop inlet sections will conform to the test and design requirements. Admixtures or blends may be used with the approval of the engineer. In no case, however, shall the proportion of portland cement in the mixture be less than 564 pounds per cubic yard (335 kg/m<sup>3</sup>) of concrete. Fly ash may be used to replace cement in accordance with the applicable provisions of [Sec 501](#). Precast concrete manhole and drop inlet sections may also be constructed of Class B or B-1 concrete. If Class B or B-1 concrete is used, material, proportioning, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#).

#### **1033.4 Design.**

**1033.4.1** The minimum compressive strength of the concrete shall be 4000 pounds per square inch (28 MPa). The minimum wall thickness for manhole sections shall be one-twelfth of the internal diameter of the riser or largest cone diameter. Wall thickness for rectangular drop inlets shall be as shown on the plans.

**1033.4.2** The circumferential reinforcement in manhole sections may consist of either one or two lines of steel. The total area of reinforcement per vertical or linear foot (meter) shall not be less than 0.0025 times the inside diameter in inches (0.2125 times the inside diameter in millimeters), or in any case, not less than 0.12 square inch per linear foot (255 mm<sup>2</sup>/m).

**1033.4.3** The quantity of steel reinforcement for rectangular drop inlets shall be as shown on the plans.

**1033.4.4** Flat slab tops shall be of the thickness shown on the plans and shall be reinforced with a layer of steel with a minimum area of 0.12 square inch per linear foot (255 mm<sup>2</sup>/m) in both directions. Openings in flat slab tops shall be additionally reinforced with a minimum of the equivalent of 0.20 square inch (133 mm<sup>2</sup>) of steel at 90 degrees. Straight rods used to reinforce openings shall have a minimum length equal to the diameter of the opening plus 2 inches (50 mm).

**1033.4.5** The circumferential reinforcement in grade rings shall have an equivalent area of not less than 0.07 square inch per linear foot (150 mm<sup>2</sup>/m), or in any case, not less than 0.024 square inch (15 mm<sup>2</sup>) in any one grade ring.

**1033.5 Modified or Special Designs.** The manufacturer may request approval of designs, prior to manufacture, other than those described in these specifications. Special or modified designs shall be submitted to the engineer, in writing and shall fully describe any deviations from these specifications. The description shall also include the wall thickness, all other dimensions, concrete compressive strength and the area, type, placement and strength of the steel reinforcement. Such sections shall meet all of the test and performance requirements specified by the engineer in accordance with [Sec 1033.2](#).

#### **1033.6 Placement of Reinforcement.**

**1033.6.1** If one line of circular reinforcement is used, the reinforcement shall be placed in the center one-third of the wall thickness. If two lines of circular reinforcement are used, each line shall be so placed that the protective covering over the circumferential reinforcement in the wall of the section shall be one inch (25 mm). Either the tongue or groove of the joint shall contain circumferential reinforcement equal in area to that of a single line within the wall of the section. The location of the reinforcement shall be subject, however, to the permissible variations in dimensions specified in [Sec 1033.10.5](#).

**1033.6.2** Placement of reinforcement in rectangular drop inlets shall be as shown on the plans.

**1033.6.3** In flat slab tops the layers of reinforcement shall be placed near the bottom surface so that the protective cover over the reinforcement shall be one inch (25 mm). The exposure of the ends of the reinforcement will not be a cause for rejection.

**1033.6.4** Reinforcement of a given total steel area may be composed of two layers if the layers are not separated by more than the thickness of one cross member plus 1/4 inch (6 mm). The two layers shall be tied together to form a single rigid cage. All other specification requirements such as laps, welds and tolerances of placement in the wall of the manhole, risers and tops, shall apply to this method of fabricating a line of reinforcement.

**1033.6.5** Each line of circumferential reinforcement shall be assembled into a cage that shall contain sufficient spacer bars or members, extending through the wall of the manhole risers and conical tops, to maintain the reinforcement rigidly in shape and correct position within the form. The exposure of the ends of stirrups or spacers that have been used to position the cages during the placement of the concrete will not be a cause for rejection.

**1033.6.6** If splices are not welded, the reinforcement shall be lapped not less than 20 diameters for deformed bars and 40 diameters for plain bars and cold-drawn wire. The spacing center to center of adjacent rings of circumferential reinforcement in a cage shall not exceed 6 inches (150 mm) for manhole risers and conical tops.

**1033.7 Joints.** The reinforced concrete riser sections, excepting grade rings, shall be so formed that when the risers and top are assembled they will make a continuous and uniform structure compatible with the tolerance specified in [Sec 1033.10.3](#). The joints shall be of such design as will permit placement without appreciable irregularities in the interior wall surface.

#### **1033.8 Manufacture.**

**1033.8.1 Placement of Concrete.** The transporting and placing of concrete shall be by methods that will prevent the segregation of the concrete material and the displacement of the reinforcing steel from the proper position in the form.

**1033.8.2 Curing.** Precast manholes and drop inlets shall be cured in accordance with [Sec 1026.16](#). Precast sections shall not be transported or erected until the design compressive strength has been reached.

**1033.8.2.1** If Class B or B-1 concrete is used, the sections shall be cured with wet burlap for 72 hours or by covering with transparent membrane applied in accordance with the requirements of [Sec 502.12.1](#). Precast units constructed with Class B or B-1 concrete shall not be transported or erected until at least seven days after casting. If forms are removed before the expiration of the curing period, the parts of the structure thus exposed shall be cured as directed by the engineer.

**1033.8.3 Lift Holes.** Lift holes shall conform to the requirements of [Sec 1026.17](#). Lifting hooks or bars may be cast into the sections, if approved by the engineer.

**1033.8.4 Forms.** Forms shall be mortar-tight and of sound material adequate to prevent distortion during placing and curing of concrete. Forms shall be reasonably smooth and free of loose knots, holes and other defects.

**1033.8.5 Cold Weather Concreting.** Concrete placed in cold weather shall be protected from freezing during the curing period by the use of a heated, weatherproof enclosure. Concrete shall not be placed on or against reinforcing steel or other surfaces with temperatures lower than 35 F (2 C). No concrete shall be placed when the ambient temperature is below 35 F (2 C).

#### **1033.9 Physical Test Requirements.**

**1033.9.1 Concrete Test Requirements.** The engineer may require compression test specimens in the quantity of 5 percent of the total number of sections for each contract, but not to exceed two cylinders for each day's production. The specified number of specimens required for the tests shall be furnished without charge by the manufacturer and shall be selected at random by the engineer. If cores are taken for compression tests they shall be from manhole or drop inlet sections that would not otherwise be rejected under this specification. The selection shall be made at the point or points designated by the engineer.

**1033.9.2 Compression Tests.** Compression tests for satisfying the design concrete strength requirement may be made on either standard rodded concrete cylinders or cylinders compacted and cured in a similar manner to the manhole or drop inlet sections or, at the option of the

manufacturer, on cores drilled from the wall of the section. If cylinders are tested, they shall be tested in accordance with the requirements of AASHTO T 22. The average compressive strength of all cylinders tested shall be equal to or greater than the design strength of the concrete. If compression test cylinders are being used, the manufacturer shall furnish a sufficient number of molds of a type meeting the approval of the engineer. If cores are obtained from the wall of the sections, they shall be cut and tested in accordance with the requirements of AASHTO T 280. The compressive strength of each core tested shall be equal to or greater than the design strength of the concrete. If a core does not meet the required strength, another core from the same section may be tested. If this core does not meet the required strength, that section will be rejected. Additional tests shall be made on other sections to determine the acceptability of the lot. If the cores cut from a section meet the strength test requirement, the core holes shall be plugged and sealed by the manufacturer in a manner such that the section will meet all of the test requirements of this specification. Manhole or drop inlet sections so sealed shall be considered as satisfactory for use.

**1033.9.3 Absorption Test Requirements.** The engineer may require samples for absorption tests if concrete other than Class B or B-1 is used. The absorption of a specimen from the wall of a section, as determined in accordance with the requirements of AASHTO T 280 shall not exceed 9 percent of the dry weight (mass). Each sample shall be a piece broken from the wall or a core drilled from the wall, have a minimum area of 9 square inches (5800 mm<sup>2</sup>) as measured on one surface of the wall, have a thickness equal to the wall and be free of visible cracks. If the initial absorption specimen from a section fails to conform to this specification, the absorption test shall be made on another specimen from the same section and the results of the retest shall be substituted for the original test results.

**1033.9.4 Retests.** If not more than 20 percent of the concrete test specimens fail to pass the requirements of this specification, the manufacturer may cull stock and may eliminate whatever quantity of sections desired and shall so mark them that they will not be shipped. The required tests will be made on the balance of the order and the sections will be accepted if they conform to the test requirements.

**1033.9.5 Test Equipment.** Each manufacturer furnishing manhole and drop inlet sections under these specifications shall furnish all facilities and personnel necessary to carry out the tests described in [Sec 1033.9.2](#) and [1033.9.3](#).

#### **1033.10 Permissible Variations in Dimensions.**

**1033.10.1** The internal dimensions of manhole and drop inlet sections shall not vary more than one percent or 3/8 inch (10 mm), whichever is greater.

**1033.10.2** The wall thickness shall not be less than that specified in [Sec 1033.4.1](#) or as shown on the plans by more than 5 percent or 3/16 inch (5 mm), whichever is greater. A wall thickness greater than that specified in [Sec 1033.4.1](#) or as shown on the plans will not be cause for rejection.

**1033.10.3** Variations in lengths of two opposite sides of manhole and drop inlet sections shall not be more than 5/8 inch (16 mm).

**1033.10.4** The vertical spacing and vertical alignment between adjacent manhole steps and horizontal distance from the inside wall to the centerline of a manhole step shall not vary more than one inch (25 mm) from the design dimensions.

#### **1033.10.5 Position and Area of Reinforcement.**



**1033.10.5.1 Position.** For sections with a 4-inch (100 mm) thickness or less, the maximum variation in the position of the reinforcement from that specified in [Sec 1033.6](#) shall be 10 percent of the thickness or 1/4 inch (6 mm), whichever is the greater. For sections with a thickness greater than 4 inches (100 mm) the maximum variation shall be 10 percent of the thickness or 5/8 inch (16 mm), whichever is the lesser. The cover over the reinforcement shall not be less than 3/4 inch (19 mm).

**1033.10.5.2 Area.** Steel areas up to 0.005 square inch per linear foot (10 mm<sup>2</sup>/m) less than that specified will be considered as meeting the required steel area.

**1033.11 Steps.** Steps for precast manholes and drop inlets shall be in accordance with [Sec 604.10](#) and as shown on the plans. Steps in riser and conical top sections shall be aligned in each section so as to form a continuous ladder with rungs equally spaced vertically in the assembled manhole at a maximum distance of 16 inches (400 mm). Steps shall be embedded in the riser or conical top section wall a minimum distance of 3 inches (75 mm). The rung or cleat shall project a minimum clear distance of 4 inches (100 mm) from the wall of the riser or cone section measured from the point of embedment.

**1033.12 Finish.** The manhole or drop inlet sections shall be substantially free of fractures, large or deep cracks and surface roughness. The planes of the ends of the sections shall be perpendicular to their longitudinal axis, within the limits of the variations specified in [Sec 1033.10.3](#).

**1033.13 Repairs.** Manhole or drop inlet sections may be repaired, if necessary, because of occasional imperfections in manufacture or accidental injury during handling and will be acceptable if, in the judgment of the engineer, the repairs are sound, properly finished and cured and the repaired manhole sections conform to the requirements of these specifications. Filling of form tie cavities and repair of other defects shall be in accordance with [Sec 703.3.15](#).

#### **1033.14 Inspection and Rejection.**

**1033.14.1 Inspection.** The quality of material, the process of manufacture and the finished manhole or drop inlet sections shall be subject to inspection and approval by the engineer.

**1033.14.2 Rejection.** Manhole or drop inlet sections shall be subject to rejection for failure to conform to any of the specified requirements. In addition, individual sections may be rejected because of any of the following:

- (a) Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.
- (b) Defects that indicate imperfect proportioning, mixing and molding.
- (c) Surface defects indicating honeycombed or open texture.
- (d) Damaged or cracked ends where such damage would prevent making a satisfactory joint.
- (e) Any continuous crack having a surface width of 0.01 inch (0.3 mm) or more and extending for a length of 12 inches (300 mm) or more, regardless of position in the section wall.

**1033.15 Marking.** The following information shall be clearly marked on the inside of each manhole or drop inlet section:

- (a) MH for manholes or DI for drop inlets.
- (b) Date of manufacture.
- (c) Name or trademark of the manufacturer.

Marking shall be indented into the section or shall be painted thereon with waterproof paint.

## SECTION 1034

### REINFORCED CONCRETE ELLIPTICAL CULVERT, STORM DRAIN AND SEWER PIPE

**1034.1 Reinforced Concrete Elliptical Culvert, Storm Drain and Sewer Pipe.** This pipe shall conform to the requirements of AASHTO M 207, except as follows:

(a) Cement shall conform to the requirements of [Sec 1019](#).

(b) Fine and coarse aggregate shall conform to the requirements of [Sec 1005](#), except that requirements for gradation and percent passing the No. 200 (75  $\mu$ m) sieve shall not apply. Both fine and coarse aggregate shall be used in the mixture.

**1034.1.1** The class of the pipe and whether Horizontal Elliptical or Vertical Elliptical shall be as specified in the contract.

## SECTION 1035

### REINFORCED CONCRETE ARCH CULVERT, STORM DRAIN AND SEWER PIPE

**1035.1 Reinforced Concrete Arch Culvert, Storm Drain and Sewer Pipe.** This pipe shall conform to the requirements of AASHTO M 206, except as follows:

(a) Cement shall conform to the requirements of [Sec 1019](#).

(b) Fine and coarse aggregate shall conform to the requirements of [Sec 1005](#), except that requirements for gradation and percent passing the No. 200 (75  $\mu$ m) sieve shall not apply. Both fine and coarse aggregate shall be used in the mixture.

**1035.1.1** The class and size of the arch pipe shall be as specified in the contract.

## SECTION 1036

### REINFORCING STEEL FOR CONCRETE

#### 1036.1 Reinforcing Steel for Concrete Structures.

**1036.1.1** Unless otherwise specified, reinforcement shall be deformed bars meeting the requirements of one of the following: AASHTO M 31, AASHTO M 42 or AASHTO M 53. Bars conforming to AASHTO M 42 and M 53 shall be in straight lengths only.

**1036.1.2** Spiral reinforcement shall conform to the requirement for reinforcing steel bars, except that the reinforcement may be plain or deformed or shall be cold drawn steel wire conforming to the requirements of AASHTO M 32 or deformed steel wire conforming to the requirements of AASHTO M 225.

**1036.1.3** Welded steel wire fabric shall conform to requirements of AASHTO M 55 or AASHTO M 221.

**1036.2 Steel Wire Fabric for Concrete Pavement.** Welded steel wire fabric reinforcement for concrete pavement shall meet the requirements of AASHTO M 55 or AASHTO M 221, except the requirements for weld shear tests and the variation of diameter of transverse wires shall be waived. The wire fabric shall be in mats of the size and design shown on the plans. It will be permissible to furnish longitudinally hinged wire fabric for sheets of a required width of 8 feet (2.5 m) or greater. The hinge shall be made by looping the transverse wires around a longitudinal wire and shall be capable of developing the full strength of the transverse wire. The hinge shall be located within one foot (300 mm) of the center of the width of the sheet. All steel wire fabric shall be free from dirt, paint, oil, grease, thick rust and other foreign substances. Thin powdery rust need not be removed.

#### 1036.3 Epoxy Coated Reinforcing Steel.

**1036.3.1** The steel shall be deformed reinforcing bars meeting the requirements of AASHTO M 31, AASHTO M 42 or AASHTO M 53. Bars conforming to AASHTO M 42 and M 53 shall be in straight lengths only.

**1036.3.1.1** The contractor and the coating applicator shall determine the actual lengths of bars to be shipped for coating. The coated bar lengths delivered to the construction site shall be as shown on the plans. Additional bars as indicated in the bar bill for each bridge shall be furnished and coated for testing purposes. These additional bars shall not be used by the coating applicator for tests but are to be furnished to the project as an integral part of the total shipment of coated reinforcing steel.

#### 1036.3.2 Inspection of Uncoated Steel.

**1036.3.2.1** If the contractor obtains the uncoated steel from a source where the engineer normally performs inspection of reinforcing steel, the engineer shall be notified when the steel is ready for inspection and the steel will be inspected and approved prior to shipment to the coating applicator.

**1036.3.2.2** If the contractor obtains the uncoated steel from a source where the engineer does not normally perform inspection, the steel may be inspected and sampled at the coating applicator's plant prior to coating, by the engineer or representative, if the engineer so elects.

In such case the engineer or representative will sample each heat and each bar size for testing. Each heat is to be properly identified by the steel manufacturer by a means such as tagging bundles or bars of each heat with the heat number. Steel that cannot be identified by heat number and source will not be inspected or accepted.

**1036.3.2.3** The engineer will inspect and sample the steel at the project site if inspection was not performed at the steel mill or at the coating applicator's plant. Samples taken at the project site for testing of steel properties will be taken at the same time as samples of the coated steel and will be from the bar size and shape listed on the bar bill that includes additional bars for testing. If any bar fails to meet all requirements for reinforcing steel, all bars of that size in the total quantity will be rejected. No additional bars will be taken for destructive testing unless requested by the contractor and no additional payment will be made for bars taken for retest. If the shipment is retested, double the number of bars taken for the original tests will be selected. All samples taken for retest shall meet all requirements or all bars of that size in the total quantity will be rejected.

**1036.3.2.4** Regardless of where the steel is sampled, the contractor shall furnish in triplicate a copy of the steel manufacturer's certified mill test report showing concrete chemical and physical test results for each heat.

**1036.3.3 Coating Process.** The epoxy powder may be applied by the electrostatic spray or electrostatic fluidized-bed method to either a hot or cold bar. The coated bar shall be given a thermal treatment specified by the manufacturer of the epoxy resin which will provide a fully cured finished coating.

**1036.3.4 Coating Material.**

**1036.3.4.1** The coating material shall be a powdered epoxy resin which has been approved by the engineer. An approved list of epoxy resins is maintained by the Division Engineer, Materials. The powdered resin shall be of the same material, quality and formulation as that approved for use by the engineer.

**1036.3.4.2** The contractor shall furnish the engineer three copies of the manufacturer's certification that the material supplied to the coating applicator conform to these specifications. The manufacturer of the epoxy resin shall supply to the coating applicator information on the resin that is considered essential to the proper use and performance of the resin as a coating. Acceptance of the coating material will be based on the manufacturer's certification and results of any tests deemed necessary.

**1036.3.5 Patching Material.** Patching or repair material, compatible with the coating and inert in concrete, shall be as recommended by the epoxy resin manufacturer. The material shall be epoxy and must be suitable for application at the plant or in the field to uncoated areas and damaged areas of the coating.

**1036.3.6 Surface Preparation.** The surface of bars to be coated shall be clean and free from rust, scale, oil, grease and similar surface contaminants. The surface shall be blasted to a near white metal in accordance with the Steel Structure Painting Council Surface Preparation Specification SSPC-SP10. All traces of grit and dust from the blasting shall be removed. The coating shall be applied to the cleaned surface as soon as possible after cleaning, before visible oxidation of the surface occurs and not more than 8 hours after cleaning unless otherwise approved by the engineer.

**1036.3.7 Coating Thickness.**

**1036.3.7.1** A film thickness after curing of 5 to 12 mils (130  $\mu\text{m}$  to 300  $\mu\text{m}$ ) shall be applied in a uniform, smooth coat. Thickness of the film shall be measured, by the applicator, on a representative number of bars from each production lot, in accordance with ASTM G 12.

**1036.3.7.2** The coating film shall be fully cured. A representative proportion of each production lot shall be checked by the coating applicator, using the method found most effective for measuring cure, to ensure that the entire production lot of coating is supplied in a fully cured condition.

**1036.3.8 Continuity of Coating.**

**1036.3.8.1** The coating shall be checked visually after cure for continuity of coating and shall be free from holes, voids, contamination, cracks and damaged areas. In addition, there shall not be more than two holidays (pinholes not visually discernible) in any linear foot (meter) of the coated bar.

**1036.3.8.2** The coating applicator shall use an in-line holiday detector with an alarm device in accordance with the manufacturer's instructions to check the coating for holidays. A 67 1/2-volt detector such as the Tinker and Rasor Model M-1 or its equivalent shall be used. If approved by the engineer, a portable holiday detector will be permitted.

**1036.3.9 Flexibility of Coating.** The coating applicator shall perform the flexibility of coating test on a representative number of bars selected from each production lot. The coated reinforcing bars shall be capable of being bent 120 degrees (after rebound) around a mandrel without any visible evidence of cracking of the coating, except that very minute hairline cracks, with no evidence of disbonding, at the base of the deformation will be permitted. The mandrel shall have a diameter specified in AASHTO M 284. The bend shall be made at a uniform rate of speed and may take up to one minute to complete. The two longitudinal deformations may be placed in a plane perpendicular to the mandrel radius. The bending test shall be conducted at room temperature after the specimen has been exposed to room temperature for a sufficient time to ensure that the specimen has reached thermal equilibrium. A temperature in the range of 68 to 85 F (20 to 30 C) shall be considered room temperature. The fracture or partial failure of the steel reinforcing bar in the bend test for flexibility of coating will not be considered as a failure of flexibility of coating. Additional bars may, however, be required for testing and evaluation of flexibility of coating.

**1036.3.10 Inspection and Testing.**

**1036.3.10.1** The contractor shall inform the engineer, in writing, at least ten days prior to performing any of the cleaning or coating operations.

**1036.3.10.2** If the engineer so elects, the preparation, coating and curing of the bars and testing for coating thickness, continuity and flexibility shall be done in the engineer's presence. The engineer shall have free access to the shop for inspection and every facility shall be extended to the engineer for this purpose. On a random basis, lengths of coated bars, other than the additional test bars, may be taken by the engineer from the production run at the point of coating application, for non-destructive test, evaluation and check purposes.

**1036.3.10.3** In lieu of shop inspection, the engineer may elect to perform all sampling and testing at the project site. On a random basis, lengths of coated bars will be taken by the engineer from the total quantity at the project site, for test, evaluation and check purposes. The engineer will perform testing for holiday detection on bars selected at random and the contractor shall provide personnel for such items as handling steel. Destructive sampling and testing will be limited to the number of bars furnished as additional bars for testing in

accordance with [Sec 1036.3.1.1](#). If any bar fails to meet all the above specified tests, all coated bars of that size will be rejected. No additional bars will be taken for destructive testing unless requested by the contractor and no additional payment will be made for bars taken for retest. If the shipment is retested, double the number of bars taken for the original tests will be selected. All samples taken for retest shall meet all requirements or all bars of that size in the total quantity will be rejected.

**1036.3.10.4** Regardless of where inspection and testing is performed, the contractor shall furnish to the engineer the coating applicator's certification in triplicate, certifying that all material used, the preparation of the bars, coating and curing conform to the requirements of these specifications and that no bar contains more than two holidays per linear foot (300 mm). The certification shall include or have attached specific results of tests of coating thickness and flexibility of coating.

**1036.3.11 Shipping.** All systems for handling epoxy coated bars shall have padded contact areas. Coated bars shall be prepared for shipment by use of excelsior or equivalent padded metal bands or other methods which will prevent damage during shipment. If bundled together for shipment, the bundles shall be small, tightly banded with padded bands and shall be lifted in a manner to prevent bar abrasion in the bar bundle and shall be stored on padded supports.



## SECTION 1037

### SHEAR CONNECTORS

**1037.1 Scope.** This specification covers the requirements for stud-type shear connectors and weldability qualification.

**1037.2 Material.** Studs shall meet the requirements of AASHTO M 169 for cold drawn carbon steel bars Grades 1015, 1017 or 1020, either semi or fully-killed. If flux retaining caps are used, the steel for the caps shall be of a low carbon grade suitable for welding and shall comply with the requirements of ASTM A 109. The flux for welding shall be self-contained either in the base of the stud or in the ferrule and automatically applied in the welding operation. A ferrule of heat resistant ceramic or other suitable material shall be used with each stud and the ferrule shall be composed of material which is not detrimental to the welds, does not cause excessive slag and which has sufficient strength to withstand thermal or structural shock.

**1037.3 Qualification Procedure.** This procedure prescribes weldability tests to qualify shear connector studs for welding under shop or field conditions. Such tests may be performed by a university, independent laboratory or by other approved testing agencies. The tests shall be made on each type and size of stud. The agency performing the tests shall submit to the manufacturer of the stud a certified report giving procedures and results for all tests including the information listed under [Sec 1037.9](#).

**1037.4 Duration of Qualification.** Qualifications are considered valid until the manufacturer makes a change in the base of the stud, the flux or the arc shield, which affects the welding characteristics.

#### **1037.5 Preparation of Specimens.**

**1037.5.1** Test specimens shall be prepared by welding representative studs to the center of square specimen plates, 1/2 to 3/4 inch (13 to 19 mm) thick, meeting the requirements of AASHTO M 183. At the option of the manufacturer, several studs may be welded to a large plate and the specimen plates cut of a size suitable for test equipment used. Studs shall be welded with power source, welding gun and control equipment as recommended by the manufacturer. Welding voltage, current and time shall be measured by suitable instrumentation and recorded for each specimen. Lift and plunge shall be at the optimum setting as recommended by the manufacturer.

**1037.5.2** Studs shall be of uniform quality and condition, free from laps, fins, seams, cracks, twists, bends or other injurious defects. The finish shall be as produced by cold drawing, cold rolling or machining. The size of studs with allowable tolerance shall be as shown in Table I. The overall height after welding will be shown on the plans.

TABLE 1			
Stud Size - Inches (mm)			
Shank Diameter	Overall Height (Tolerance After Welding)	Head Diameter	Head Thickness, Min
+ .000 3/4 (19) - .010 (- 2.5)	+ .062 (+ 1.6) - .125 (- 3.2)	1 1/4 ± 1/64 (32 ± 0.40)	3/8 (9.5)
+ .000 7/8 (22) - .010 (- 2.5)	+ .062 (+ 1.6) - .125 (- 3.2)	1 3/8 ± 1/64 (35 ± 0.40)	3/8 (9.5)

**1037.5.3** Thirty test specimens shall be welded consecutively with optimum current and time. Optimum current and time shall be the mid-point of the range normally recommended by the manufacturer for production welding.

**1037.5.4** Thirty test specimens shall be welded consecutively with time held constant at optimum but with current 10 percent below optimum.

**1037.5.5** Thirty test specimens shall be welded consecutively with time held constant at optimum but with current 10 percent above optimum.

#### **1037.6 Qualification Tests.**

**1037.6.1 Tensile Tests.** Ten of the specimens welded in accordance with [Sec 1037.5.3](#), ten in accordance with [Sec 1037.5.4](#) and ten in accordance with [Sec 1037.5.5](#), shall be subjected to a tensile test. A stud will be considered as qualified if all test specimens meet the following requirements:

Tensile Strength, min	60,000 psi (414 MPa)
Yield Strength*, min	50,000 psi (345 MPa)
Elongation, min	20% in 2 inches (50 mm)
Reduction of Area, min	50%

\*As determined by a 0.2% offset method.

Tensile properties shall be determined in accordance with the applicable sections of AASHTO T 244. If a fracture occurs outside the middle half of the gage length, the test shall be repeated.

**1037.6.2 Bend Tests.** Twenty of the specimens welded in accordance with [Sec 1037.5.3](#), twenty in accordance with [Sec 1037.5.4](#) and twenty in accordance with [Sec 1037.5.5](#), shall be bent alternately 30 degrees in opposite directions until failure occurs. A stud will be considered as qualified if, on all test specimens, fracture occurs in the shank of the stud and not in the weld.

**1037.7 Retests.** If a weld failure occurs in any of the tensile or bend test groups, another test group may be prepared and tested. If weld failure repeats, the stud shall fail to qualify.

**1037.8 Qualification.** For a manufacturer's studs and arc shields to be qualified, each group of thirty studs shall, by test or retest, meet the requirements specified in [Sec 1037.6](#).

**1037.9 Report of Tests.** The report of the testing laboratory to the manufacturer shall include the following:

- (a) Drawings which show shapes and dimensions with tolerances of studs, arc shields and flux.

- (b) A complete description of material used in the studs and arc shields, including the quantity and analysis of the flux.

- (c) A certification that the studs and arc shields described in the report are qualified in accordance with [Sec 1037.8](#).

**1037.10 Certification.** Prior to inspection, the contractor shall submit to the engineer the following information:

- (a) The name of the manufacturer.

- (b) A detailed description of the studs to be furnished.

- (c) A certification from the manufacturer that the studs delivered are qualified in accordance with [Sec 1037.8](#).

- (d) A copy of the qualification test results as certified by the testing laboratory unless the source and manufacturing process for these studs has been previously approved.

- (e) Certified copies of in-plant quality control test results.

## SECTION 1038

### BEARING PADS FOR STRUCTURES

**1038.1 Scope.** These specifications cover elastomeric bearing pads of neoprene, of rubber and fabric and of rubber and fiber. Elastomeric bearing pads as herein specified shall include plain bearings (consisting of elastomer only) and laminated bearings (consisting of layers of elastomer restrained at their interfaces by bonded laminates).

#### **1038.2 Elastomeric Bearing Pads.**

**1038.2.1 Material.** The elastomer shall be 100 percent virgin chloroprene (neoprene) compound meeting the requirements listed in Table I. The pads shall be of the Durometer Grade specified on the plans. If test specimens are cut from the finished product, a 10 percent variation in "Physical Properties" will be allowed.

<b>TABLE I</b>				
<b>ASTM Standard</b>		<b>Durometer Grade</b>		
		<b>50</b>	<b>60</b>	<b>70</b>
D 2240	Hardness	50±5	60±5	70±5
D 412	Tensile Strength, psi (MPa), min	2500 (17.2)	2500 (17.1)	2500 (17.2)
D 412	Ultimate Elongation, percent, min	400	350	300
D 573 70 hours @ 212 F (100 C)	Heat Resistance Change in Durometer Hardness, Points, max Change in Tensile Strength, percent, max Change in Ultimate Elongation, percent, max	+15 -15 -40	+15 -15 -40	+15 -15 -40
D 395 Method B	Compressive Set 22 hours at 212 F (100 C), percent max	35	35	35
D 1149	Ozone 100 pphm ozone in air by volume, 20 percent strain 100F ± 2F (37.7 ± 1C), 100 hours, mounting procedure ASTM D 518 Procedure A	No Cracks	No Cracks	No Cracks
D 429 Method B	Adhesion Bond made during vulcanization, lb per in (N/m)	40 (7.010)	40 (7.010)	40 (7.010)
D 746, Procedure B	Low Temperature Test Brittleness at -40 F (-40 C)	No Failure	No Failure	No Failure

Laminates shall be rolled mild steel sheets, of ASTM Grade A 36 equivalent or better, conforming to ASTM A 569, A 570 Grade 36, A 611 Grade D or A 607 Grade 50.

**1038.2.2 Manufacturing Requirements.** Plain bearings may be molded individually, cut from previously molded strips or slabs or extruded and cut to length. Cut edges shall be at

least as smooth as ANSI 250 (6  $\mu\text{m}$ ) finish. Unless otherwise shown on the plans, all components of a laminated bearing shall be molded together into an integral unit and all edges of the laminations shall be covered by a minimum of 1/8 inch (3 mm) of elastomer except at laminate restraining devices and around holes that will be entirely closed on the finished structure. The following values shall be met under laboratory testing conditions of full size bearings.

(a) Compressive strain of any layer of an elastomeric bearing shall not exceed 7 percent at 800 pounds per square inch (5.5 MPa) average unit pressure or at the design dead load plus live load pressure, if so indicated on the plans.

(b) Shear resistance of the bearing shall not exceed 50 pounds per square inch (345 kPa) for 50 durometer, 75 pounds per square inch (520 kPa) for 60 durometer or 110 pounds per square inch (760 kPa) for 70 durometer compounds at 25 percent strain of the total effective elastomer thickness after an extended 4-day ambient temperature of -20 F (-29C).

**1038.2.3 Tolerances.** For both plain and laminated bearings, the permissible variation from the dimensions and configuration shown on the plans shall be as follows:

	Inch (Millimeter)
Overall Vertical Dimensions	
Average total thickness 1 1/4 inches (32 mm) or less	-0, +1/8 (-0, +3)
Average total thickness over 1 1/4 inches (32 mm)	-0, +1/4 (-0, +6)
Overall Horizontal Dimensions	
36 inches (914 mm) and less	-0, +1/4 (-0, +6)
Over 36 inches (914 mm)	-0, +1/2 (-0, +12)
Thickness of Individual Layers of Elastomer (Laminated bearings only)	$\pm 1/8$ ( $\pm 3$ )
Variation from a Plane Parallel to the Theoretical Surface (as determined by measurements at the edges of bearings)	
Top	1/8 (3)
Sides	1/4 (6)
Individual non-elastic laminates	1/8 (3)
Position of Exposed Connection Members	1/8 (3)
Edge Cover of Embedded Laminates or Connection Members	-0, +1/8 (-0, +3)
Size of Holes, Slots or Inserts	-0, +1/8 (-0, +3)
Position of Holes, Slots or Inserts	$\pm 1/8$ ( $\pm 3$ )

### 1038.3 Rubber and Fabric Pads.

**1038.3.1** Rubber and fabric bearings pads shall be manufactured of new material and be composed of multiple layers of prestressed cotton duck weighing not less than 8.1 ounces per square yard (0.2746 kg/m<sup>2</sup>). The duck warp count shall be 50 threads plus or minus one thread per inch (25 mm) and filing count 40 threads plus or minus two threads per inch (25 mm), each with two yarns per thread. The finished pads shall have 64 plies per inch (25 mm) of thickness. The duck material shall be impregnated and bound with a high quality rubber compound containing rot and mildew inhibitors and anti-oxidants, compounded into resilient pads of uniform thickness.

**1038.3.2** The pads shall withstand compressive loads perpendicular to the plane of laminations of not less than 10,000 pounds per square inch (69 MPa) without separation of

bond or detrimental deformation. Load deflection properties, determined in accordance with procedures of Military Specifications MIL-C-882B, shall not exceed the following percentages of total pad thickness: 10 percent at 1000 pounds per square inch (6.9 MPa), 15 percent at 2000 pounds per square inch (14 MPa). When loaded to 1500 pounds per square inch (10 MPa), permanent set as load is removed in accordance with procedures of MIL-C-882B, shall be not more than 2.5 percent of the original "zero point" thickness. Type A Durometer hardness shall be 87 to 95. The ratio of lateral expansion to vertical deflection shall not exceed 0.25 when loaded to 1500 pounds per square inch (10 MPa). The material shall not lose effectiveness throughout a temperature range of -65 F to 150 F (-54 to 66 C). The thickness shall not vary more than 5 percent from that shown on the plans. There shall be no visible evidence of damage or deterioration resulting from environmental effects of sunshine, humidity, salt spray, fungus or dust in accordance with MIL-E-5272.

#### **1038.4 Rubber and Fiber Pads.**

**1038.4.1** Rubber and fiber bearing pads shall consist of a rubber body and fabric fibers for insulation under aluminum rail posts. They shall be made from new unvulcanized rubber and unused fabric fibers. Fibers and rubber shall be in proper proportion to maintain specified strength and stability.

**1038.4.2** Type A durometer surface hardness of the pads shall be 70 to 90. Pads of the specified thickness shall be capable of withstanding compressive loads of not less than 7000 pounds per square inch (48 MPa) without excessive extrusion or detrimental reduction in thickness.

**1038.5 Dimensions.** Bearing pads shall be furnished to the specified dimensions with all anchor bolt holes accurately located.

**1038.6 Certification.** The contractor shall furnish a manufacturer's certification in triplicate, showing typical test results representative of the material and certifying that the material supplied conforms to all of the requirements specified.

## SECTION 1039

### EPOXY RESIN MATERIAL

#### 1039.1 Type II Epoxy.

**1039.1.1 Scope.** This specification covers two-component epoxy resin to be used to bond plastic concrete or mortar to hardened concrete or mortar.

**1039.1.2 General Requirements.** The epoxy shall be furnished as a two-component system and shall comply with the requirements of ASTM C 881, Type II.

**1039.1.2.1** The system shall comply with the requirements for Grade 2, Class B or C.

**1039.1.3 Manufacturer and Brand Name Approval.** Prior to approval and use of this material, the manufacturer shall submit in triplicate to the Division Engineer, Materials, a certified test report showing specific test results conforming to all requirements of these specifications. The certified test report shall contain the manufacturer's name, brand name of material, lot tested, date of manufacture and ratio of components. In addition, the manufacturer shall submit a one quart (liter) sample of each component, A and B, for laboratory testing accompanied by a technical data sheet and a material safety data sheet. Upon approval by the engineer of the certified test report and satisfactory results of tests performed on the sample submitted, the brand name and manufacturer will be placed on a prequalified list of concrete bonding compounds. New certified test results and samples shall be submitted any time the manufacturing process or the material formulation is changed and may be required when random sampling and testing of material offered for use indicates nonconformity with any of the requirements herein specified.

**1039.1.4 Material Certification.** To obtain final acceptance of this material, the manufacturer shall furnish a certification in triplicate to the engineer at destination certifying that the material supplied conform to all requirements specified and stating that the material is formulated the same as the material tested for manufacturer and brand name approval.

#### 1039.2 Type III Epoxy.

**1039.2.1 Scope.** This specification covers two-component epoxy to be used in the grouting of dry cracks, in epoxy mortar for patching concrete and in epoxy mortar surface leveling.

**1039.2.2 General Requirements.** The epoxy shall be furnished as a two-component system and shall conform to the requirements of ASTM C 881, Type III.

**1039.2.2.1** The system shall comply with the requirements for Grade 1, Class B or C.

**1039.2.3 Manufacturer and Brand Name Approval.** Prior to approval and use of this material, the manufacturer shall submit in triplicate to the Division Engineer, Materials, a certified test report showing specific test results conforming to all requirements of these specifications. The certified test report shall contain the manufacturer's name, brand name of material, lot tested, date of manufacture and ratio of components. In addition, the manufacturer shall submit a one quart (liter) sample of each component, A and B, for laboratory testing accompanied by a technical data sheet and a material safety data sheet. Upon approval by the engineer of the certified test report and satisfactory results of tests performed on the sample submitted, the brand name and manufacturer will be placed on a

prequalified list of concrete bonding compounds. New certified test results and samples shall be submitted any time the manufacturing process or the material formulation is changed and may be required when random sampling and testing of material offered for use indicates nonconformity with any of the requirements herein specified.

**1039.2.4 Material Certification.** To obtain final acceptance of this material, the manufacturer shall furnish a certification in triplicate to the engineer at destination certifying that the material supplied conform to all requirements specified and stating that the material is formulated the same as the material tested for manufacturer and brand name approval.

### **1039.3 Epoxy or Polyester Bonding Agents for Dowels.**

**1039.3.1 Scope.** This specification covers a two-component epoxy or polyester bonding agent to be used in anchoring epoxy coated dowel bars in concrete for pavement repair.

**1039.3.2 General Requirements.** Epoxy or polyester bonding agents for anchoring epoxy coated dowel bars shall be furnished as a two-component system. The system shall include automatic mixing, whether in cartridge or bulk form. The component ratios shall be shown on the label of each cartridge or bulk container.

**1039.3.3 Properties.** The epoxy or polyester bonding agent shall exhibit good bonding properties between the epoxy coated dowel bar and the existing concrete and shall cure in two (2) hours or less. Bonding agents, when initially mixed, shall have a viscosity which prevents flow from a horizontal hole. When tested in accordance with MoDOT Test Method T49, the minimum pull-out load shall be 8100 pounds (36 kN).

**1039.3.4 Manufacturer and Brand Name Approval.** Prior to approval and use of this material, the manufacturer shall submit in triplicate to the Division Engineer, Materials, a certified test report from an approved independent testing laboratory showing specific test results conforming to all requirements of this specification. The certified test report shall contain the manufacturer's name, brand name of material, lot tested, date of manufacture, ratio of components by volume and system tested. In addition, the manufacturer shall submit to the Division Engineer, Materials, a sample representing the system tested by the independent testing laboratory and accompanied by a system data sheet, a material safety data sheet and any special installation instructions relative to the system being submitted, including recommended curing time. Upon approval of the system, the brand name will be placed on a list of prequalified bonding agents for dowels.

**1039.3.5 Acceptance.** To obtain final acceptance of this material, the manufacturer shall furnish a certification to the engineer at destination certifying that the material supplied conforms to all requirements specified and stating that the material supplied is the same system and is formulated the same as the material tested for manufacturer and brand name approval.



## SECTION 1040

### GUARDRAIL AND GUARD CABLE MATERIAL

**1040.1 Wood Posts.** Wood posts for guardrail and guard cable shall conform to the requirements of [Sec 1050](#).

**1040.2 Steel Posts.** Posts shall be structural steel, meeting the requirements of AASHTO M 183. Posts shall be of the dimensions and weights (masses) shown on the plans and shall be galvanized in accordance with the requirements of AASHTO M 111. Anchor bolts, nuts and washers shall conform to the dimensions shown on the plans and shall be galvanized in accordance with requirements of AASHTO M 232, or they may be mechanically galvanized. If mechanically galvanized, the coating thickness, adherence and quality requirements shall conform to AASHTO M 232, Class C.

#### **1040.3 Steel Beam Guardrail.**

**1040.3.1 General.** This specification covers two classes and two types of guardrail beams.

Class A - 12 Gage - base metal nominal thickness, 0.105 inch (2.67 mm).

Class B - 10 Gage - base metal nominal thickness, 0.135 inch (3.43 mm).

Type 1 - Zinc coated, 1.80 ounces per square foot (550 g/m<sup>2</sup>), minimum single-spot.

Type 2 - Zinc coated, 3.60 ounces per square foot (1100 g/m<sup>2</sup>), minimum single-spot.

Guardrail beams shall be of the class (gage) shown on the plans. They shall be galvanized in accordance with the requirements for Type 1 except that, at the option of the contractor, beams coated in accordance with the requirements for Type 2 may be supplied.

**1040.3.2 Base Metal.** The beam elements shall consist of sheet made of open hearth, electric furnace or basic oxygen steel.

**1040.3.2.1** The mechanical properties of the base metal for beams shall conform to the following tensile requirements.

Yield Point, minimum, 50,000 psi (345 MPa).

Tensile Strength, minimum, 70,000 psi (483 MPa).

Elongation, 2-inch (50 mm), minimum, 12 percent.

**1040.3.2.2** Test specimens for mechanical properties shall be prepared and tested as specified in ASTM A 924.

### 1040.3.3 Sheet or Beam Thickness.

**1040.3.3.1** The thickness for the finished beam or sheet shall conform to the requirements specified in Table I.

<b>TABLE I</b>			
<b>Sheet or Beam Thickness</b>			
<b>Class of Beam</b>	<b>Type of Coating</b>	<b>Thickness, in. (mm)</b>	<b>Tolerance Under Specified Thickness, in. (mm). No limit for over thickness.</b>
A	1	0.108 (2.74)	0.009 (0.23)
	2	0.111 (2.82)	0.009 (0.23)
B	1	0.138 (3.51)	0.010 (0.25)
	2	0.141 (3.58)	0.010 (0.25)

**1040.3.3.2** For fabricated beams, thickness measurements will be made on tangent portions of the cross-section.

**1040.3.4 Sheet Width.** The beam elements shall be formed from sheets having nominal widths of 19 inches (483 mm) for W beams and 29 1/2 inches (749 mm) for thrie beams. A tolerance of minus 1/8 inch (3 mm) from the nominal width will be permissible.

### 1040.3.5 Galvanized Beams.

**1040.3.5.1** The beams may be galvanized before or after fabrication. The zinc used for the coating shall be Prime Western Spelter or better conforming to the requirements of AASHTO M 120.

**1040.3.5.2** The weight (mass) of coating shall conform to the requirements specified in Table II. The weight (mass) of coating is the total quantity of galvanizing on both sides of a sheet or beam, expressed as ounces per square foot (g/m<sup>2</sup>) of sheet.

<b>TABLE II</b>	
<b>Weight (Mass) of Coating</b>	
<b>Type</b>	<b>Check Limit Single-Spot Test oz/ft<sup>2</sup> (g/m<sup>2</sup>), min.</b>
1	1.80 (550)
2	3.60 (1100)

**1040.3.5.3** The sheets or beams shall be of prime finish, that is, free from injurious defects such as blisters, flux and uncoated spots. Uncoated edges resulting from shearing or punching will be acceptable.

**1040.3.5.4** The coating shall be smooth, free of beading or sharp projections along the edges, and shall adhere tenaciously to the surface of the metal.

**1040.3.5.5** The test specimen size and method of tests for determining the weight (mass) of coating shall be in accordance with AASHTO T 65. At the option of the engineer, material may be accepted on the basis of magnetic gauge determinations made in accordance with ASTM E 376.

**1040.3.6 End Sections.** End sections, buffer ends, end shoes and terminal connectors shall be formed of material of a class and type the same as or superior to that used for the beam to which they are attached.

**1040.3.7 Fabrication.** The beams, end sections, buffer ends, end shoes and terminal connectors shall be shaped and punched in conformance with the requirements shown on the plans. They shall be ready for assembly when delivered. Only drilling or cutting necessary for special connections and for sampling will be permitted in the field. Warped or deformed beams will be rejected. Beams to be erected on a radius of 150 feet (46 m) or less shall be shop curved to the approximate curvature of the installation.

**1040.3.8 Connections and Splices.** All beam connections or splices shall be formed with oval shoulder button headed bolts to minimize projections on the traffic face of guardrail. Bolts and nuts shall conform to the requirements of ASTM A 307, and shall be galvanized in accordance with the requirements of AASHTO M 232, or they may be mechanically galvanized. If mechanically galvanized, the coating thickness, adherence and quality requirements shall conform to AASHTO M 232, Class C.

**1040.3.9 Washers and Back-Up Plates.** Washers shall be as shown on the plans. Washers shall be galvanized in accordance with the requirements of AASHTO M 232. Back-up plates shall consist of one-foot (305 mm) sections of beams and shall be of the same class and type specified for the full length beams.

**1040.3.10 Anchor Plates, Bearing Plates and Soil Plates.** Anchor plates, bearing plates and soil plates shall be fabricated as shown on the plans, of steel conforming to the requirements of AASHTO M 183. They shall be galvanized in accordance with requirements of AASHTO M 111.

**1040.3.11 Steel Tube for Breakaway Cable Terminal and End Anchor.** The steel shall consist of structural steel tubing conforming to the requirements of ASTM A 500 Grade B or ASTM A 501 and shall be galvanized in accordance with the requirements of AASHTO M 111.

**1040.3.12 Marking.**

**1040.3.12.1** Each beam element shall be identified by the following:

- (a) Name or Brand of Manufacturer.
- (b) Identification Symbols or Code for Heat Number and Coating Lot.
- (c) AASHTO Specification Number.
- (d) Class and Type.

If approved by the engineer, the AASHTO specification number may be omitted, and other designations for Class and Type may be used.

**1040.3.12.2** Markings shall not be placed at such location that they will be obscured after erection, or in a manner that the brand will be conspicuous to any traffic. Markings placed on the traffic face of the beam shall be placed in the valley of the center corrugation and shall be die imprinted with letters and numerals not exceeding one-half inch (13 mm) high.

**1040.3.12.3** Marking material shall be such as to resist obliteration during storage, transportation and erection.

**1040.3.12.4** Markings for end sections, buffer ends, end shoes and back-up plates may be on durable tags securely attached to each section or to each bundle. Markings shall include name or brand of manufacturer, Class and Type. Heat numbers and coating designations are not required.

**1040.3.13 Basis of Acceptance.**

**1040.3.13.1** All material shall be subject to inspection and sampling at the fabricating plant or warehouse, or after delivery to the site of construction. The contractor or supplier shall provide equipment and personnel required to obtain samples as directed by the engineer.

**1040.3.13.2 Acceptance by Sampling.** The engineer may take one piece of guardrail beam, a back-up plate, an end section, a buffer end and an end shoe from each 200 pieces in a lot, or from each lot if less than 200 pieces are included therein, for determination of compliance with specification requirements. If one piece fails to meet requirements, two other pieces shall be tested. If either of these pieces fails to conform to the requirements of this specification, the lot of material represented by these samples will be rejected. A lot shall be considered that quantity of material, offered for inspection at one time, which bears the same heat and coating identification.

**1040.3.13.3 Acceptance by Brand Registration and Guarantee.**

**1040.3.13.3.1** By mutual agreement between the fabricator and engineer, acceptance may be based upon a Brand Registration and Guarantee filed with the Division Engineer, Materials, by the fabricator. For acceptance of a brand, the fabricator shall furnish a Brand Registration and Guarantee meeting the approval of the engineer and showing the brand name or designation, the manner in which the brand name or designation will appear on the fabricated beams, the typical mechanical properties, chemical composition if specified, the class and type of guardrail, and other specified properties. The fabricator shall also guarantee that as long as material is furnished under that brand and designation, the material will conform fully to the requirements of the specifications and shall be replaced without cost to the Commission when found not in conformity with any of the specified requirements. The Brand Registration and Guarantee shall be sworn to for the fabricator by a person having legal authority to bind the company. Upon approval of a Brand Registration and Guarantee, that brand will be accepted without further certification. If, in subsequent actual field use, there is evidence of misbranding, as determined by random sampling and detection of inadequate tensile strength, yield strength, elongation, improper chemical composition, inadequate or improper coating, deficient thickness or improper fabrication, the material will be rejected and approval for further use withdrawn until subsequently reapproved. Samples for tests of any material offered for use may be taken at any time deemed desirable by the engineer.

**1040.3.13.3.2** The manufacturer or fabricator shall make such tests and measurements as necessary to ensure that the material produced complies with all specification requirements. These tests and measurements shall be so identified by the identification symbols or code used on the beam that the manufacturer can produce specific reports showing these test results. Copies of reports of these tests shall be kept on file and shall be submitted to the engineer upon request.

**1040.3.13.3.3** The brand shall be removed or obliterated by the manufacturer or fabricator on all material where control tests, as outlined herein, do not show conformance to this specification.

**1040.4 Channel Rail.** Channel rail for guardrail shall be structural steel meeting the requirements of AASHTO M 183. Rail shall be galvanized in accordance with the

requirements of AASHTO M 111. Bolts, nuts and washers shall be galvanized in accordance with the requirements of AASHTO M 232, or they may be mechanically galvanized. If mechanically galvanized, the coating thickness, adherence and quality requirements shall conform to AASHTO M 232, Class C. Bolts shall conform to the dimensions shown on the plans.

**1040.5 Blocks.** Wood blocks for guardrail shall conform to the requirements of [Sec 1050](#). Steel blocks for guardrail shall conform to the requirements of [Sec 1040.2](#).

**1040.6 Repair of Galvanizing.** All galvanized material for guardrail shall be handled in a manner to avoid damage to the surfaces. Any galvanized material on which the spelter coating has been bruised or broken will be rejected or may, with the approval of the engineer, be repaired by the metallizing process in accordance with [Sec 1020](#), or by the zinc alloy stick method in accordance with [Sec 712](#).

**1040.7 Cable and Fittings.**

**1040.7.1** Cable for guard cable shall be zinc coated steel wire strand; 1/2 inch (12.7 mm) in diameter; seven wire strand; Common, Siemens-Martin or High Strength grade; Class A coating; and shall conform to the requirements of ASTM A 475.

**1040.7.2** Cable for breakaway cable terminals and end anchors shall be 3/4 inch (19 mm) in diameter, Type II, Class A conforming to AASHTO M 30.

**1040.7.3** Eyebolts, turnbuckles and clips for cable connections and end anchors shall be steel forgings conforming to the requirements of AASHTO M 102, or may be pearlitic malleable iron conforming to the requirements of ASTM A 220. All miscellaneous parts comprising cable connections, fasteners and end anchors shall be galvanized in accordance with the requirements of AASHTO M 232.

**1040.8 Certifications.** If requested by the engineer, the contractor shall furnish manufacturer's certifications in triplicate, which state that the material supplied will conform to the requirements of these specifications. The certifications shall include, or have attached, specific results of laboratory tests for specified physical and chemical properties as determined from samples representative of the material. Test data required will be designated by the engineer.

## SECTION 1041

### CONSTRUCTION SIGNS

**1041.1 Scope.** This specification covers signs for warning and control of traffic during highway construction.

**1041.2 Signs and Sign Panels.** All signs shall be fabricated of mild steel, aluminum or of 5/8-inch or 3/4-inch (16 mm or 19 mm), 5-ply, high density type overlaid Douglas Fir plywood. Metal signs may have embossed borders or legends. All signs shall be fabricated to provide satisfactory structural rigidity.

**1041.3 Reflectorizing.** All signs shall have a reflectorized background unless otherwise shown on the plans. Reflective sheeting shall meet the requirements of [Sec 1042.2.7](#), Type 1.

**1041.4 Legend and Borders.** Legend and borders of all signs shall be made from vinyl or painted by use of silk screen process, except that roller application for embossed legend or borders will be permitted. Vinyl shall be cut by die or a computer driven cutter. Paint shall be good quality, commercially available, stencil ink or paint. Free-hand legend and borders will not be permitted.

**1041.5** Legends, dimensions and colors shall be in accordance with the plans or as directed by the engineer.

**1041.6 Certification.** The contractor shall furnish a manufacturer's certification in triplicate, showing typical test results representative of the material and certifying that all material supplied conform, to all of the requirements specified. The contractor shall also furnish the engineer the fabricators certification in triplicate stating "I hereby certify that only those materials conforming to Missouri Standard Specifications, [Sec 1041](#), construction signs were used in the fabrication of the signs and the manufacturing processes used were in full compliance with the specification requirements".

## SECTION 1042

### HIGHWAY SIGN MATERIAL

**1042.1 Scope.** These specifications cover the material used in signs and fastening devices, and the fabrication of the signs.

**1042.2 Material.** Material shall be of new stock and shall conform to the following unless otherwise shown on the plans.

#### 1042.2.1 Signs.

Item	Specification
Aluminum Flat Sheets	ASTM B 209, 6061-T6 or 5052-H38
Aluminum Extruded Sign Panels	ASTM B221, 6063-T6

#### 1042.2.2 Sign Appurtenances.

Item	Specification
Aluminum Post Clip	ASTM B 108, 356-T6
Aluminum Bolts	ASTM B 211, 2024-T4 or 6061-T6
Aluminum Nuts	ASTM B 211, 2024-T4, 6061-T6, 6262-T9 or 2017-T4
Aluminum Flat Washers	ASTM B 209, or Alclad 2024-T4 or 2024-T4
Aluminum Lock Washers	ASTM B 211, 7075-T6
Aluminum Lock Nuts (Nylon Insert)	ASTM B 211, 2017-T4
Aluminum Cutout Letters, Figures, Borders and Corners	ASTM B 209
Aluminum Edge Molding	ASTM B 221, 6063-T6
Stainless Steel Bolts, Nuts, Screws and Washers	ASTM A 320 or SAE J405D, Austenitic Steel, Min Yield 30,000 psi (206 MPa)
Vulcanized Fiber Washers Commercial Grade	ASTM D710 Gray

**1042.2.3** A manufacturer's or supplier's Certification of Metal used for signing material listed above shall be furnished to the engineer, at the fabrication plant at the time of inspection of the material. The contractor shall furnish the engineer the fabricator's certification in accordance with [Sec 903.3.5.2](#).

**1042.2.4** Structural signs shall be fabricated of minimum 0.081 inch (2.1 mm) extruded aluminum panels and mounted as shown on the plans. Maximum allowable deviation from flatness shall not exceed 0.010 inch per inch (0.25 mm per 25 mm) width of the panel. Shop drawings for approval of the engineer will be required for any variations in the assembly or mounting details.

**1042.2.5** Flat sheet signs shall be fabricated as shown on the plans from sheet aluminum of the specified thickness. Flat sheet signs shall have no holes except those drilled or punched for proper mounting.

**1042.2.6** Fiber or nylon washers shall be used between the bolt heads and sign faces on flat sheet aluminum signs. The washers shall be for use with 3/8-inch (9.5 mm) bolts and have a minimum outside diameter of 3/4 inch (19 mm), and a nominal thickness of 1/16 inch (1.5 mm).

**1042.2.7** Reflective sheeting shall have a precoated pressure sensitive adhesive or a tack free heat activated adhesive backing, neither of which shall require additional adhesive coats on the reflective sheeting or application surface. The protective liner attached to the adhesive shall be easily removed by peeling without soaking in water or other solvents. The adhesive shall form a durable bond to clean substrates and shall adhere securely under all atmospheric conditions of field exposure. Reflective sheeting applied to cleaned and etched aluminum test panels shall adhere securely after 48 hours of aging, at temperatures of -20 F to 150 F (-29 to 65 C). The adhesive bond shall be sufficient to render the applied sheeting vandal-resistant and prevent its shocking off when struck by foreign objects. Reflective sheeting shall have sufficient strength and flexibility so that the sheeting can be handled, processed and applied according to the manufacturer's recommendations without appreciable stretching, tearing, cracking or other damage. The sheeting surface shall be readily screen processed and compatible with recommended transparent and opaque screen process colors. The reflective sheeting manufacturer shall furnish information as to the type of solvent or solvents that may be used to clean the surface of the sheeting without detrimental loss of brightness and durability.

**1042.2.7.1** Type 1 reflective sheeting shall consist of spherical lens elements embedded within transparent plastic having a smooth, flat outer surface which shall be weather resistant.

**1042.2.7.2** Type 2 reflective sheeting shall consist of spherical lens elements adhered to a synthetic resin and encapsulated by a flexible, transparent, weather resistant plastic having a smooth outer surface.

**1042.2.7.3** The reflective sheeting shall have a minimum coefficient of retroreflection as shown in Table I or II, expressed as candelas per footcandle per square foot (candelas/lux/m<sup>2</sup>) in accordance with MoDOT Test Method T8.

<b>TABLE I</b>								
<b>Type 1 Reflective Sheeting</b>								
<b>Minimum Coefficient of Retroreflection</b>								
<b>Observation Angle, Degrees</b>	<b>Entrance Angle, Degrees</b>	<b>White</b>	<b>Brown</b>	<b>Yellow</b>	<b>Orange</b>	<b>Red</b>	<b>Green</b>	<b>Blue</b>
0.2	-4	70.0	1.0	50.0	25.0	14.5	9.0	4.0
0.2	+30	30.0	0.3	22.0	7.0	6.0	3.5	1.7
0.5	-4	30.0	0.3	25.0	13.5	7.5	4.5	2.0
0.5	+30	15.0	0.2	13.0	4.0	3.0	2.2	0.8



TABLE II							
Type 2 Reflective Sheeting							
Minimum Coefficient of Retroreflection							
Observation Angle, Degrees	Entrance Angle, Degrees	White	Yellow	Orange	Red	Green	Blue
0.2	-4	250	170	100	45	45	20
0.2	+30	150	100	600	25	25	11
0.5	-4	95	62	30	15	15	7.5
0.5	+30	65	45	25	10	10	5.0

**1042.2.7.4** The daytime color of the reflective sheeting shall be as shown in Table III.

TABLE III												
Color	Chromaticity Coordinates*								Reflectances		References**	
	(Corner Points)								Limits (%Y)			
	1		2		3		4		Y		Standard	
	x	y	x	y	x	y	x	y	Min.	Max.	(Munsell Papers)	
Whites**	.303	.287	.368	.353	.340	.380	.274	.316	27	-	5.0PB	7/1
Red	.613	.297	.708	.292	.636	.364	.558	.352	2.5	11	7.5R	3/12
Orange	.550	.360	.630	.370	.581	.418	.516	.394	14	30	2.5YR	5.5/14
Yellow	.498	.412	.557	.442	.479	.520	.438	.472	15	40	1.25Y	6/12
Green	.030	.380	.166	.346	.286	.428	.201	.776	3	8	10G	3/8
Blue	.144	.030	.244	.202	.190	.247	.066	.208	1	10	5.8PB	1.32/6.8

\* The four pairs of chromaticity coordinates determines the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminations Source C.

\*\* Silver white is an acceptable color designation.

\*\*\* Available from Munsell Color Company, 2441 Calvert Street, Baltimore, Maryland 21218.

**1042.2.7.5** After two years of 45-degree south-facing outdoor exposure, reflective sheeting shall have a coefficient of retroreflection not less than 50 percent of the original reading for Type 1 or 80 percent of the original reading for Type 2. Reflective sheeting shall comply with the requirements of Table III, before and after the 2-year exposure.

**1042.2.8 Type of Characters.** Letters, numerals, arrows, symbols, borders and other features of the sign message shall be of the type, size and series shown on the plans or as specified by the engineer. Completed letters, numerals and other units shall be formed to provide continuous stroke width with smooth edges and shall present a flat surface free of warp, blisters, wrinkles, burrs and splinters. Units of the sign message of the type shown on the plans shall meet the requirements for the specified type. Type L-1, L-2, L-3 or L-4 characters shall not be intermixed on a single sign face unless otherwise shown on the plans or as approved by the engineer.

**1042.2.8.1 Type L-1, Screen Processed Characters.** The letters, numerals, arrows, symbols and borders shall be applied to the background of the sign by direct or reverse screen process. Messages and borders of a color darker than the sign field shall be applied to the reflective sheeting by direct process. Messages and borders of a color lighter than the sign field shall be produced by the reverse screen process. Inks used in the silk screen process shall be of the type to produce the desired color and durability when applied on reflective sheeting. Silk screen inks shall be used in accordance with the manufacturer's recommendations. The ink shall produce the desired color when applied on reflective sheeting background and shall dry

within 18 hours to a good film without running, streaking or sagging. The screening shall be done in a manner which results in a uniform color and tone, with sharply defined edges of legend and border, and without blemishes on the sign field that will affect intended use. Signs after screening shall be air-dried or baked in accordance with the manufacturer's recommendations to provide a smooth hard finish. Any signs on which blisters appear during the drying process will be rejected.

**1042.2.8.2 Type L-2, Demountable Characters.** The letters, numerals, symbols, borders and other features of the sign message shall be Type 2 reflective sheeting applied to a flat aluminum sheet with the equipment and in a manner prescribed by the sheeting manufacturer. The aluminum sheet shall be a minimum of 0.032 inch (0.8 mm) thick. Spacing of mounting holes shall be determined by character size and shape but in no case shall be more than 8 inches (200 mm) on centers. Each character shall be secured to the sign with 1/8 inch (3 mm) diameter aluminum blind rivets with aluminum mandrels.

**1042.2.8.3 Type L-3, Direct Applied Characters.** The letters, numerals, symbols, borders and other features of the sign message shall be cut from the color and type of sheeting shown on the plans and applied to the sign field in accordance with instructions of the manufacturer of the sheeting.

**1042.2.8.4 Type L-4, Acrylic Plastic Characters.** The letters, numerals, symbols, borders and other features of the sign message shall consist of embossed aluminum frames in which prismatic reflectors are installed so as to be an integral part of the character or otherwise affixed to prevent their displacement in handling or service. Reflectors which are held in the frames by means of tape or adhesive will not be accepted. All items shall be fabricated from a minimum 0.040 inch (1.016 mm) thick sheet aluminum and shall be treated with a chromate conversion coating prior to painting. Paint shall be non-chalking white, meeting or exceeding Federal Specification TT-E-489 G Class B. Mounting holes shall be provided within frames to permit the use of 1/8 inch (3 mm) diameter aluminum blind rivets having 5/32 inch (4 mm) diameter shoulders and aluminum mandrels. The holes shall not be spaced more than 8 inches (200 mm) center to center. The size and spacing of reflector holes shall be such as to afford night legibility and visibility to the finished cut-out figure. The reflectors shall consist of a clear and transparent plastic face, herein referred to as the lens, and an opaque back fused to the lens under heat and pressure around the entire perimeter to form a homogeneous unit permanently sealed against dust, water and water vapor. The reflector lens shall be made of methyl methacrylate. The lens shall consist of a smooth front surface free from projections or indentations other than for identification and a rear surface bearing a prismatic configuration such that it will effect internal reflection of light. Fifty-three samples of each size will be selected by the engineer at random from each shipment for the various tests. Sample size and acceptance practice will be the same regardless of the size of the shipment unless otherwise specifically permitted by the engineer. Reflectors selected for inspection and testing shall be replaced by the contractor and affixed in the frames as specified for new characters.

(a) Each reflex reflector shall have a minimum specific brightness as shown in the following table, expressed as candelas per footcandle per square inch (candelas/lux/m<sup>2</sup>) in accordance with MoDOT Test Method T8.

Observation Angle Degree	Entrance Angle Degrees	Specific Brightness
1/10	0	14.0
1/10	20	5.6
1/3	0	7.0
1/3	20	2.8

Failure to meet the minimum coefficient of retroreflection values shall constitute failure of a reflector and failure of more than two reflectors shall be cause for rejection of the lot. Optical testing shall be in accordance with MoDOT Test Method T8.

(b) To determine if reflectors are adequately sealed against dust, water and water vapor, 50 reflectors shall be immersed in water at room temperature in an airtight container and the pressure reduced to 25 inches (625 mm) of mercury for five minutes. Atmospheric pressure shall be restored and the samples shall remain immersed for an additional five minutes. They shall then be examined for water intake. Any evidence of water or water vapor in a reflector shall constitute failure and failure of more than two reflectors shall be cause for rejection of the lot.

(c) Heat resistance testing shall be as follows: Three reflectors of each size shall be placed in a circulating oven for four hours at 145 F to 155 F (63 to 68 C). The test specimens shall be placed in a horizontal position on a grid or perforated shelf permitting free air circulation. After the heating period, the samples shall be removed from the oven and permitted to cool in air to room temperature. The samples at the conclusion of the test shall show no significant change in shape and general appearance. Failure of one sample shall be cause for rejection of the lot.

**1042.2.8.5** The following variations in dimensions of letters and numerals, regardless of type, will be acceptable with all measurements made to the nearest 1/8 inch (3 mm).

Nominal Height, in. (mm)	Variation in Height, in. (mm)	Variation in Width, in. (mm)
4 thru 12 (100 thru 300)	-1/8 to +3/8 (-3 to +9.5)	-1/4 to +1/4 (-6 to +6)
Over 12 (Over 300)	-1/8 to +3/8 (-3 to +9.5)	-3/8 to +3/8 (-9.5 to +9.5)

The design height of rounded letters or numerals shall be 1/64 inch per inch (0.4 mm per 25 mm) of height greater than normal height, both on top and bottom of letter or numeral, where rounded. The loop portion of letters such as f, g and y, shall conform to the dimensions shown on the plans with the allowable tolerance.

**1042.2.9** Reflectors used in delineators shall conform to the requirements of [Sec 1042.2.8](#) and shall have a minimum coefficient of luminous intensity as shown in the following table, expressed as candelas per footcandle (lux) in accordance with MoDOT Test Method T8. A white or pastel acrylic opaque plastic back will not be required if the lens is permanently and durably sealed against dust, water and water vapor in a manner approved by the engineer.

ENGLISH				
Observation Angle, Degrees	Entrance Angle, Degrees	Minimum Coefficient of Luminous Intensity		
		Crystal *(White)	Amber	Red
1/10	0	115	70	30
1/10	20	45	25	12
1/3	0	50	30	12
1/3	20	20	12	5
METRIC				
Observation Angle, Degrees	Entrance Angle, Degrees	Minimum Coefficient of Luminous Intensity		
		Crystal *(White)	Amber	Red
1/10	0	10.7	6.5	2.8
1/10	20	4.2	2.3	1.1
1/3	0	4.7	2.8	1.1
1/3	20	1.9	1.1	0.5

The color of the reflector lens shall be as shown on the plans. Failure to meet the coefficient of luminous intensity minimum shall constitute failure of a reflector and failure of more than two reflectors of the 50 subjected to test shall be cause for rejection of the lot.

**1042.3 Sign Fabrication.** A sign shall consist of aluminum flat sheets or extruded panels reflectorized on the face side with all letters, numerals, symbols, borders, corners and route shields mounted on the face, and shall include all necessary mounting devices as shown on the plans. Signs with an area of 30 square feet (3 m<sup>2</sup>) or more are structural (ST) and shall be fabricated with extruded panels. Signs with an area of less than 30 square feet (3 m<sup>2</sup>) are sheet (SH) signs and shall be fabricated with flat sheet.

**1042.3.1** The signs shall be reflectorized as follows.

**1042.3.1.1** All aluminum panels shall be given a chromate conversion treatment conforming to the requirements of ASTM B 449. All surfaces of aluminum panels shall be prepared by a process which includes, as a minimum, the following steps:

(a) Preclean. Where foreign matter such as oils and greases are particularly heavy, solvent vapor degreasing, solvent washing or solvent emulsion cleaning shall be used prior to alkaline cleaning.

(b) Predip. Heat-treatable alloys to be cleaned by alkaline etching shall be predipped in an acid deoxidizer for 15 seconds to 2 minutes and sprayed or immersed in clean overflowing water until the surface is free of water breaks.

(c) Alkaline Type Cleaner (Immersion or Spraying). The temperature of the cleaner and transfer time between the cleaner and rinse shall be such as to avoid drying of cleaner on the aluminum surface. The aluminum surface shall be sprayed or immersed in clean overflowing water until free of water breaks.

(d) Deoxidize. Acid deoxidizer treatment by immersion or spraying. The aluminum surface shall be sprayed or immersed in overflowing water until thoroughly clean and be free of water breaks.

(e) Chromate Treatment. The aluminum surface shall be given a chromate conversion coating which, after rinsing and drying, shall produce a uniform, tight, powder free coating meeting the requirements of Class 2 Coatings, ASTM B 449. The coating weight (mass) shall be 10 to 35 milligrams per square foot (107 to 376 mg/m<sup>2</sup>). The aluminum surface shall be sprayed or immersed in clean overflowing water and air or oven dried. The temperature of the metal shall not exceed 160 F (71 C).

The chemicals and solvents shall be applied in strict accordance with the directions of the manufacturer. Sufficient laboratory facilities to test and control the concentration of the solutions used shall be maintained at the treating plant. A log of the concentration of treating solutions shall be maintained. Treated panels shall be handled with clean mechanical devices or workers with clean gloves. Panels shall be stored in a dry, clean area free from dust, acid fumes or vapors. Where aluminum is shipped to a secondary location for reflectorizing, adequate precautions shall be taken to ensure that the material arrives at destination uncontaminated.

**1042.3.1.2** Reflective sheeting splices on structural signs shall be kept to a minimum. Only sheeting manufacturer's rolled overlap splices shall be used with no more than one allowed per panel. Reflective sheeting shall be placed horizontally on the individual extruded panels with

a 1/2 inch (13 mm) overlap on each edge. No reflective sheeting will be permitted over the butt joints of adjacent extruded panels. The sign panels shall be clear coated or edge sealed after application of the reflective sheeting, if recommended by the sheeting manufacturer. The completed sign shall have good color matching of reflective sheeting and be free from cracks, tears, blisters, bubbles and wrinkles.

**1042.3.1.3** Reflective sheeting applied to standard flat sheet signs shall have no splices except on signs where the smallest dimension is greater than 4 feet (1200 mm). One vertical overlap splice approximately 1/4 inch (6 mm) wide will be acceptable on standard flat sheet signs where the smallest dimension is greater than 4 feet (1200 mm). Any special flat sheet signs requiring splicing other than noted for the standard flat sheet signs shall be as approved by the engineer. The sign panels shall be clear coated or edge sealed after application of the reflective sheeting, if recommended by the sheeting manufacturer. If clear finish is used, the finish shall be applied after screening of messages and borders. If edge sealer is used, the sealer shall be applied to all splices and edges. The completed sign face shall be free from cracks, tears, blisters, bubbles and wrinkles.

**1042.3.2** Nuts on panel bolts shall be torqued to 20 - 30 pounds (2.3 - 3.4 Nm).

**1042.3.3** Periodic shop inspection of sign fabrication will ordinarily be made at the fabricating shop, but in some cases may be waived and complete inspection made when the fabricated signs are delivered to the site of the work. The engineer shall be notified well in advance of beginning of shop work so adequate arrangements may be made for inspection. It is understood that whether or not shop inspection is made, workmanship and material which do not conform to the requirements of the specifications and recognized good practice may be rejected at any time prior to acceptance of the work.

**1042.3.3.1** The contractor will be charged with transportation costs of sign inspectors for trips made from Jefferson City to points to which they must travel for shop inspection work. The routine shop inspection work will include inspection and sampling of material, inspection of treatment and fabrication processes, and of any signs completed at time of inspection. In general, two round trips for one inspector will be required. Transportation costs will be deducted by the Commission from monies due the contractor.

## SECTION 1043

### FENCE MATERIAL

**1043.1 Scope.** These specifications cover the material required in the construction of chain-link fence and woven wire fence.

#### Chain-Link Fence Material

**1043.2 Chain-Link Fence Description.** Chain-link fence and gates shall be comprised (1) of fabric composed of individual pickets helically wound and interwoven in the form of a continuous chain-link fabric without knots or ties except knuckling or twisting at the ends of pickets to form the selvage of the fabric, and (2) of posts, rails, ties, bands, bars, rods, tension wire and other fittings and hardware.

**1043.2.1 Fabric General Requirements.** Fabric shall consist of wire woven into the form of approximately uniform square mesh, having parallel sides and horizontal and vertical diagonals of approximately uniform dimensions.

**1043.2.1.1** The mesh size shall be 2 inches (50.8 mm), measured in either direction as the minimum clear distance between the wires forming the parallel sides of the mesh. A variation of mesh size of plus or minus 1/8 inch (3.2 mm) will be permitted.

**1043.2.1.2** The height of fabric shall be the overall dimension from ends of twists or knuckles, measured without tension applied. A variation in height of plus or minus one inch (25 mm) will be permitted.

**1043.2.1.3** Chain-link fabric shall be fabricated from wire with diameters as necessary to meet the requirements of Table I. A variation of plus or minus 0.005 inch (0.127 mm) will be permitted. For zinc coated or aluminum coated fabric, the specified diameter is the coated wire diameter and the permissible tolerance is applied to the coated wire. For vinyl coated (PVC) fabric the specified diameter is the metallic coated core wire and the permissible tolerance is applied only to the metallic coated core wire. The thickness of the PVC coating will not be used in determining wire size. For aluminum alloy fabric, the specified diameter is the finished wire.

**1043.2.1.4** Wire used for fabric shall meet the minimum breaking load as shown in Table II.

**1043.2.1.5** Fabric less than 72 inches (1829 mm) high shall be knuckled at both selvages. Fabric 72 inches (1829 mm) high or higher shall be knuckled at one selvage and twisted at the other. Knuckling is the selvage obtained by interlocking adjacent pairs of wire ends and bending the wire back into a loop. Twisting is the selvage obtained by twisting adjacent pairs of wire ends and bending together in a close helix of 1 1/2 machine turns, which is the equivalent of three full twists, and cutting the wire ends at an angle with the ends beyond the twist at least 1/4 inch (6 mm) long.

**1043.2.2 Zinc Coated Steel Fabric.** Wire used for zinc coated chain-link fabric may be coated before or after weaving into fabric. Fabric that is zinc coated after weaving shall be hot-dip galvanized in a continuous process and the coating shall not be applied to the fabric in roll form. Wire that is zinc coated before weaving into fabric may be either hot-dip galvanized or electrolytically zinc-plated. The weight (mass) of zinc coating shall not be less than 2.0 ounces per square foot (610 g/m<sup>2</sup>) of uncoated wire surface, determined from the

average of all specimens representing the lot and not less than 1.8 ounces per square foot ( $550 \text{ g/m}^2$ ) on an individual specimen. Excessive lumps, beads and drops of zinc will be excluded in determining weight (mass) of coating.

**1043.2.3 Aluminum Coated Steel Fabric.** Wire used for aluminum coated chain-link fabric shall be coated by the hot-dip process before weaving into fabric. The weight (mass) of aluminum coating shall not be less than 0.40 ounce per square foot ( $122.1 \text{ g/m}^2$ ) of uncoated wire surface on 0.148 inch (3.76 mm) or 0.192-inch (4.88 mm) specified diameter wire and 0.35 ounce per square foot ( $106.8 \text{ g/m}^2$ ) of uncoated wire surface on 0.120-inch (3.05 mm) specified diameter wire, determined from the average of all specimens representing the lot. An individual specimen shall not have less than 0.30 ounce per square foot ( $92 \text{ g/m}^2$ ) of uncoated wire surface on 0.148 or 0.192-inch (3.76 or 4.88 mm) specified diameter wire and not less than 0.25 ounce per square foot ( $76.3 \text{ g/m}^2$ ) on 0.120-inch (3.05 mm) specified diameter wire.

**1043.2.4 Vinyl Coated Steel Fabric.** Wire used for vinyl coated chain-link fabric shall be coated before weaving into fabric. Vinyl used for coatings shall be polyvinyl chloride (PVC) and shall be plasticized and thoroughly compounded so there is full dispersement of pigments, stabilizers and other components. The color shall be uniformly green. The PVC coating shall meet the requirements of AASHTO M 181 for adhesion, accelerated aging, mandrel test and green color.

**1043.2.4.1** Extruded or extruded and bonded PVC coated wire shall be coated with zinc or aluminum by either the hot-dip or electrolytic process prior to being coated with PVC. The weight (mass) of zinc or aluminum and thickness of PVC shall be as shown in Table III.

**1043.2.4.2** Bonded PVC coated wire shall be coated with zinc by either the hot-dip or electrolytic process prior to having a PVC coating thermally fused and bonded to a primer that has been thermally cured onto the zinc coated wire. The weight (mass) of zinc or aluminum and thickness of PVC coating shall be as shown in Table III.

**1043.2.5 Aluminum Alloy Fabric.** Wire used for aluminum alloy fabric shall be aluminum alloy. The finished fabric shall be of uniform quality and have the properties and characteristics herein specified.

**1043.2.6 Posts, Braces, Rails and Gate Frames.** These members shall be of the shape and dimension as shown on the plans and shall be steel or aluminum alloy complying with the requirements of these specifications. Steel members shall have an interior and exterior coating as herein specified. These members may be used with either zinc coated, aluminum coated, aluminum alloy or vinyl coated fabric.

**1043.2.6.1** A tolerance of minus 5 percent from the specified weight (mass) and dimensions will be permitted for steel posts, rails or gate frames fabricated from ASTM F 1083 steel pipe. A tolerance of minus 5 percent from the specified weight (mass) will be permitted for other allowed steel shapes or steel tubing. Tolerances in dimensions of steel tubing and formed shapes will be as shown on the plans. A tolerance from the specified dimensions for aluminum alloy posts, rails or gate frames will be permitted in accordance with ANSI H35.2.

**1043.2.6.2** For any allowed shape of steel posts, rails or gate frames, other than ASTM F 1083, Schedule 40 steel pipe, the product of the yield strength multiplied by the section modulus shall not be less than the section modulus of pipe of an equivalent outside diameter and meeting the dimension requirements of ASTM F 1083, Schedule 40 pipe, multiplied by 25,800 pounds per square inch (178 MPa). The base metal shall be of good quality weldable steel.

**1043.2.6.3 Zinc Coated Steel Members.** A hot-dip zinc coating shall be applied uniformly to all surfaces in conformance with AASHTO M 111, except the weight (mass) of zinc coating shall not be less than 1.80 ounces per square foot ( $550 \text{ g/m}^2$ ), determined from the average of all specimens representing the lot and not less than 1.60 ounces per square foot ( $490 \text{ g/m}^2$ ) on an individual specimen. The weight (mass) of coating shall be calculated by dividing the total weight of zinc, inside plus outside, by the total area, inside plus outside, of the surface coated.

**1043.2.6.4 Zinc Plus Organic Coated Steel Members.** The members shall be pipe or tubing manufactured by roll forming steel sheet and electric resistance welding. The exterior surface shall be hot-dip zinc coated and then topcoated with organic material. The inside surface of the pipe shall have either a zinc-rich organic coating or a hot-dip zinc coating. Types of inside organic coatings and zinc plus organic exterior coating systems shall be approved by the engineer prior to being considered for use. The coatings shall also comply with the requirements of these specifications.

**1043.2.6.4.1** The weight (mass) of hot-dip zinc coating on the exterior surface shall be a minimum of 0.9 ounce per square foot ( $270 \text{ g/m}^2$ ) determined from the average of all specimens representing the lot and not less than 0.8 ounce per square foot ( $240 \text{ g/m}^2$ ) on an individual specimen. The exterior zinc coating shall be given a uniform conversion coating to enhance adhesion of the organic topcoat. The conversion coating may be applied as a separate treatment or simultaneously with the organic topcoat.

**1043.2.6.4.2** The thickness of the exterior organic topcoat shall be a minimum of 0.3 mil ( $7.620 \text{ }\mu\text{m}$ ) except the organic topcoat tradenamed DiawaKote shall be a minimum of 0.03 mil ( $0.762 \text{ }\mu\text{m}$ ).

**1043.2.6.4.3** Inside surfaces with a zinc-rich organic coating shall have a coating thickness of 0.3 mil ( $7.620 \text{ }\mu\text{m}$ ) minimum. The dried coating shall be a minimum of 87 percent zinc powder by weight (mass).

**1043.2.6.4.4** Inside surfaces with a hot-dip zinc coating shall have a minimum weight (mass) of coating of 0.35 ounce per square foot ( $107 \text{ g/m}^2$ ) determined from the average of all specimens representing the lot and not less than 0.25 ounce per square foot ( $76 \text{ g/m}^2$ ) on an individual specimen.

**1043.2.6.5 Aluminum-Coated Steel Members.** The members shall be pipe or tubing manufactured by roll forming aluminum precoated steel sheet and electric resistance welding. A hot-dip aluminum coating shall be uniformly applied to all surfaces and the outside surface of the weld area shall be metallized with pure aluminum. The weight (mass) of aluminum coating, other than the weld area shall not be less than 0.65 ounce per square foot ( $198 \text{ g/m}^2$ ), determined from the average of all specimens representing the lot and not less than 0.60 ounce per square foot ( $183 \text{ g/m}^2$ ) on an individual specimen. The weight (mass) of coating shall be calculated by dividing the total weight (mass) of aluminum, inside plus outside, by the total area, inside plus outside, of the surface coated.

**1043.2.6.6 Aluminum Alloy Members.** Aluminum posts, brace rails and gate frames shall be of aluminum alloy having a minimum tensile strength of 30,000 pounds per square inch (207 MPa), a minimum yield strength of 25,000 pounds per square inch (172 MPa), and a minimum elongation of 8 percent.

**1043.2.7 Tension Wire.** Tension wire shall be of steel coil spring wire with a coated wire diameter of 0.177 inch (4.496 mm) plus or minus 0.005 inch (0.127 mm) and shall have a minimum breaking load of 1950 pounds force (8.7 kN). The tension wire shall have a zinc



coating of not less than 0.80 ounce per square foot (240 g/m<sup>2</sup>) of uncoated wire surface or an aluminum coating of not less than 0.40 ounce per square foot (120 g/m<sup>2</sup>) of uncoated wire surface.

**1043.2.8 Fabric Fasteners.** Fabric fasteners shall consist of wire ties, hog rings and C-clips. Fasteners for use with zinc or aluminum coated steel fabric shall conform to [Sec 1043.2.8.1](#) or [1043.2.8.2](#); those for use with aluminum alloy fabric shall conform to [Sec 1043.2.8.2](#); and those for use with vinyl coated steel fabric shall conform to [Sec 1043.2.8.3](#). Fasteners shall be capable of withstanding a 180 degree bend over its own diameter without fracture of the wire or loss of adherence of coating. The wire shall have a finished or coated diameter of not less than 0.143 inch (3.632 mm), except C-clips for attaching fabric to H section posts shall have a finished or coated diameter of not less than 0.187 inch (4.750 mm). Aluminum alloy C-clips will not be permitted for fastening fabric to H section posts.

**1043.2.8.1 Zinc or Aluminum Coated Fabric Fasteners.** The wire shall be zinc coated at a rate of not less than 0.70 ounce per square foot (210 g/m<sup>2</sup>) or aluminum coated at a rate of not less than 0.30 ounce per square foot (91.5 g/m<sup>2</sup>).

**1043.2.8.2 Aluminum Alloy Fabric Fasteners.** The wire shall be of aluminum alloy having a minimum tensile strength of 16,000 pounds per square inch (110 MPa).

**1043.2.8.3 Vinyl Coated Fabric Fasteners.** The wire may be of steel or aluminum alloy and shall be uniformly coated with the same vinyl material as used to coat the fence fabric. Vinyl coating thickness shall be a minimum of 0.010 inch (254 µm). Aluminum alloy wire shall have a minimum tensile strength of 16,000 pounds per square inch (110 MPa).

**1043.2.9 Miscellaneous Fittings and Hardware.** Miscellaneous fittings and hardware may be zinc coated steel or aluminum alloy. Aluminum alloy fittings shall not be used with zinc coated steel posts, rails or gate frames.

**1043.2.9.1 Zinc Coated Steel Fittings and Hardware.** Miscellaneous steel fittings and hardware shall be of commercial grade steel or better quality, wrought or cast as appropriate to the article, and sufficient in strength and other properties to provide a balanced design when used with fabric, posts and wires of the qualities specified herein. All steel fittings and hardware including any items less than 1/8 inch (3 mm) thick shall be protected with a zinc coating conforming to the requirements of AASHTO M 111, except the weight (mass) of zinc coating shall not be less than 1.80 ounces per square foot (549 g/m<sup>2</sup>), determined from the average of all specimens representing the lot and not less than 1.60 ounces per square foot (488 g/m<sup>2</sup>) on an individual specimen.

**1043.2.9.2 Aluminum Alloy Fittings and Hardware.** Miscellaneous aluminum fittings and hardware shall be wrought or cast aluminum alloy conforming to the requirements set forth in Table IV.

**1043.2.10 Gates.** Frames shall be fastened at the corners by clamps and braces or by welding. If corners are to be welded, the ends of the vertical members shall be hemispherically notched, by removal of metal, to fit snugly to the horizontal members. The joint shall be uniformly and continuously fillet welded. The welded area and adjacent damaged coating shall be recoated by the hot-dip process or metallizing process; or covered with two coats of zinc-rich paint. The material for repair of welded areas and applications shall meet the approval of the engineer. Each gate frame shall be cross braced with not less than two 3/8-inch (9.5 mm) adjustable truss rods. The filler for gates shall be chain-link fabric of the same kind used for the fence. This filler shall be attached to the frame with stretcher bars and wire ties or clamps. Gates 6 feet (1828 mm) high or less shall be equipped with two

hinges, and gates more than 6 feet (1828 mm) high shall have three hinges. All gates, walk and drive, shall be equipped with a latch and locking attachment. Gatekeepers and center rests of an approved design shall be installed for double drive gates.

**1043.2.11 Barbed Wire.** Barbed wire for use with chain-link fence shall be zinc-coated steel, aluminum coated steel or aluminum alloy. Zinc coated barbed wire shall consist of two No. 12 1/2, 13 1/2 or 15 1/2 (2.51 mm, 2.18 mm or 1.70 mm) gage line wires twisted with 4-point barbs uniformly spaced approximately 4 or 5 inches (100 or 125 mm) apart and shall conform to requirements of AASHTO M 280 except the minimum weight (mass) of coating shall be 0.80 ounce per square foot (245 g/m<sup>2</sup>) of uncoated wire surface for all gages. Aluminum coated barbed wire shall conform to the requirements for zinc coated barbed wire except that the coating shall be aluminum alloy. The weight (mass) of coating per square foot (square meter) of surface shall not be less than 0.25 ounce (75 g/m<sup>2</sup>) for both line wires and barbs. However, barbs of suitable aluminum alloy will be permitted. Aluminum alloy barbed wire shall be aluminum alloy 5052-H38, ASTM B 211. Aluminum alloy barbed wire shall consist of two 0.110-inch (2.794 mm) line wires twisted with 4-point 0.080-inch (2.032 mm) diameter wire barbs spaced 5 inches (125 mm) apart.

### **Woven Wire Fence Material**

**1043.3 Woven Wire Fence Description.** Woven wire fence shall be composed of woven wire, barbed wire, brace wire, posts, ties, fittings and hardware.

**1043.3.1 Fabric.** The fabric shall be made of zinc coated or aluminum coated steel wire. Zinc coated fabric shall conform to the requirements of AASHTO M 279, for Design Number 939-6-11, Grade 60 or 939-6-12.5, Grade 125. The minimum weight (mass) of zinc coating shall be Class 3 for all gages. Line wires shall have tension curves. Aluminum coated fabric shall conform to the requirements for zinc coated fabric except that the coating shall be aluminum alloy applied at the rate of not less than 0.25 ounce per square foot (75 g/m<sup>2</sup>) of uncoated wire surface.

**1043.3.2 Barbed Wire.** Barbed wire for use with zinc coated steel fabric or aluminum coated steel fabric shall conform to the requirements of [Sec 1043.2.11](#).

**1043.3.3 Wood Posts.** Wood posts and braces shall conform to the requirements of [Sec 1050.2.3](#).

**1043.3.4 Steel Posts.** Steel posts and braces shall conform to the requirements of [Sec 1043.2.6](#). Corner, end and pull posts shall be pipe of the sizes and weights (masses) shown on the plans. Line posts shall be of the lengths and shapes shown on the plans. They shall have a nominal weight (mass) of 1.33 pounds per linear foot (1.98 kg/m) and a minimum weight (mass) of 1.28 pounds per linear foot (1.90 kg/m), exclusive of anchor plate.

**1043.3.5 Post Tops and Miscellaneous Hardware.** Post tops and miscellaneous fittings and hardware shall conform to the requirements of [Sec 1043.2.9.1](#).

**1043.3.6 Brace Wire.** Brace wire shall not be less than 0.143-inch (3.632 mm) diameter and of material conforming to the requirements of [Sec 1043.3.1](#).

**1043.3.7 Staples.** Staples shall be of the screw shank type or equivalent, a minimum of 1 1/4 inches (30 mm) long, galvanized and of good commercial quality.

**1043.3.8 Wire Ties.** Wire used for ties shall conform to the requirements of [Sec 1043.2.8](#) except that the wire may have a minimum diameter of 0.115 inch (2.921 mm).

**1043.3.9 Gates.** Gates for woven wire fence shall conform to the requirements of [Sec 1043.2.10](#) except that the filler shall be woven wire fabric meeting these specifications.

### **Workmanship and Finish**

**1043.4** Fabrication of chain-link or woven wire fencing material furnished under these specifications shall conform to the sizes, shapes and dimensions shown on the plans and shall show careful finished workmanship. Excessive roughness, blisters, sal-ammoniac spots, bruises, flaking, voids in coating, frozen knuckles or other defects if present to any considerable extent shall provide a basis for rejection. Polyvinyl chloride coating shall be without voids and without tears or cuts that reveal the substrate. Welded seam pipe shall have smooth welds without skips or gaps. Non-uniform or damaged organic topcoats shall provide a basis for rejection whether caused by fabrication, shipping or handling on the job. All burrs at the ends of posts and rails shall be removed.

### **Sampling and Testing**

**1043.5 Sampling.** The engineer will determine the sample size and frequency.

**1043.6 Testing.** When fencing material are tested, the tests shall be in accordance with the following methods.

**1043.6.1** Weight (mass) of hot-dip zinc coatings shall be determined in accordance with AASHTO T 65 or, at the option of the engineer, material may be accepted on the basis of magnetic gauge determinations made in accordance with ASTM E 376.

**1043.6.2** Thickness of zinc-rich organic coating shall be determined by magnetic gauge determinations made in accordance with ASTM E 376.

**1043.6.3** Weight (mass) of aluminum coating shall be determined in accordance with AASHTO T 213 or, at the option of the engineer, material may be accepted on the basis of magnetic gauge determinations made in accordance with ASTM E 376.

**1043.6.4** Thickness of organic topcoat shall be determined by first determining the total thickness of the organic topcoat and exterior hot-dip zinc coating by magnetic gauge determinations made in accordance with ASTM E 376, then chemically stripping the organic topcoat and determining the thickness of only the exterior hot-dip zinc in accordance with AASHTO T 65 or ASTM E 376. The difference between the two measurements is the thickness of the organic topcoat.

**1043.6.5** Tensile strength or breaking load - AASHTO T 68.

### **Inspection**

**1043.7** The engineer shall have free entry, at all times, to all parts of the manufacturer's or fabricator's works that concern the manufacture or fabrication of material furnished under this specification. Each product or article furnished under this specification shall be subject to inspection at the factory, fabricating plant, in laboratories of the engineer's choosing or at the point of delivery. The engineer reserves the right to sample and test each product or article subsequent to acceptance at the place of manufacture or fabrication, to determine conformance with the requirements of this specification, or to verify a certification.

## Certification

**1043.8** Certifications in triplicate are required as follows.

**1043.8.1 Vinyl Coated Material.** The contractor shall submit to the engineer a certification certifying that the vinyl material and vinyl coated fabric meets the requirements of these specifications. If vinyl coated items other than chain-link fabric are furnished, a certification is also required.

**1043.8.2 Aluminum Alloy Material.** The contractor shall submit to the engineer a certification certifying that the material conforms to the requirements specified and shall include or have attached typical physical properties representative of the material.

**1043.8.3 Organic Topcoated Material.** The contractor shall submit to the engineer a certification certifying that the material conforms to the requirements specified and that the material is the same as prequalified by the engineer.

## Packaging and Marking

**1043.9** Packaging and marking of the material shall provide ease of handling, storage and identification.

**1043.9.1** Each length of chain-link fabric, woven wire fabric or barbed wire shall be tightly rolled and firmly tied. Each roll shall carry a tag showing, as applicable to the product, the length, kind of base metal, type of coating, specified wire size, mesh size, design (style), height or width of fabric, and the producer name, brand or trademark of the manufacturer.

**1043.9.2** Each bundle or container of posts, hardware and fittings shall be marked with the name, brand or trademark of the manufacturer, type of material (steel, cast iron, aluminum alloy number, etc.), type of coating and any additional data required for proper identification or to determine apparent conformance to specified quality requirements.

<b>TABLE I</b>		
<b>Wire Size and Height of Fabric</b>		
<b>Specified Diameter<sup>a</sup></b>		<b>Height of Fabric, in. (mm)</b>
<b>in. (mm)</b>	<b>Gage</b>	
0.120 (3.048)	11	36, 42 (914, 1068)
0.148 (3.759)	9	48, 60 (1219, 1524)
0.192 (4.877)	6	72, 84 (1829, 2134)

<sup>a</sup> See [Sec 1043.2.1.3](#) for definition of specified diameter and tolerances.

<b>TABLE II</b>				
<b>Breaking Load of Wire</b>				
<b>Specified Diameter</b>		<b>Breaking Load, min., lbf (N)</b>		
<b>in. (mm)</b>	<b>Gage</b>	<b>Zinc Coated and Aluminum Coated</b>	<b>Aluminum Alloy</b>	<b>PVC Coated<sup>a</sup></b>
0.120 (3.05)	11	850 (3780)	610 (2713)	850 (3780)
0.148 (3.76)	9	1290 (5738)	930 (4136)	1290 (5738)
0.192 (4.88)	6	2170 (9652)	1560 (6939)	2170 (9652)

<sup>a</sup> The PVC coating may be mechanically or chemically removed prior to testing, if desired.

TABLE III			
PVC Coated Wire Coating Thickness and Weight (Mass)			
		PVC Thickness, Range	
Specified Diameter of Metallic Coated Core Wire <sup>a</sup> in. (mm)	Weight (Mass) of Zinc or Aluminum Coating of Uncoated Wire Surface, min., oz/ft <sup>2</sup> (g/m <sup>2</sup> )	Bonded Coatings in. (mm)	Extruded or Extruded and Bonded Coatings, in. (mm)
0.120 (3.05)	0.30 (91.5)	0.006 - 0.010 (0.15 - 0.25)	0.015 - 0.025 (0.38 - 0.64)
0.148 (3.76)	0.30 (91.5)	0.006 - 0.010 (0.15 - 0.25)	0.015 - 0.025 (0.38 - 0.64)
0.192 (4.88)	0.40 (122.1)	All Gages	All Gages

<sup>a</sup> The PVC coating shall not be used when determining wire size.

TABLE IV			
Miscellaneous Aluminum Alloy Fittings and Hardware			
		Aluminum Alloy	
Item	Type of Material	Alloy & Temper	ASTM Designation
Rail and Brace Ends, Post Tops and Turnbuckles	Castings	356.0-T6 712.0-T5, 713.0-T5, A360.0, 360.0, 413.0	B26, B85, B108
Gate Hinges, Barbed Wire Extension Arms and Other Fittings	Castings	Same as above	----
Stretcher Bars and Bands	Bar	6063-T6	B 221
Truss or Brace Rods		6061-T6	B 221
Flat Band Ties	Sheet	3003-H14	B 209
Bolts		2024-T4	F 468
Nuts		6061-T6	F 467

## SECTION 1044

### STEEL POSTS FOR MARKERS AND DELINEATORS

**1044.1 Scope.** These specifications cover galvanized steel posts used for mounting mile and object markers, delineators, drain and right of way markers and for similar purposes.

**1044.2 General Requirements.** Posts shall be of rerolled rail steel or an equivalent steel conforming to the mechanical requirements of ASTM A 499, Grade 60 and to the chemical requirements of ASTM A 1.

**1044.3 Shape and Dimensions.** Posts shall be of a channel or modified channel section.

**1044.3.1** Posts for mile markers, object markers and delineators shall be of the dimensions and weights (masses) shown on the plans.

**1044.3.2** Posts for drain and right of way markers shall weigh (have a mass) not less than 1.80 nor more than 2.25 pounds per foot (2.68 nor more than 3.35 kg/m), all tolerances included, and shall be of the lengths shown on the plans. Permissible variations in length shall be a maximum of one inch (25 mm) under and 2 inches (50 mm) over that shown. Posts shall have not less than five 3/8-inch (9.5 mm) holes, drilled or punched, along the centerline of the web. Holes shall be on 2-inch (50 mm) centers beginning one inch (25 mm) from the top of posts. Anchors or pointed ends on posts will not be required.

**1044.4 Galvanizing.** Posts shall be galvanized after fabrication in accordance with the requirements of AASHTO M 111.

**1044.5 Samples and Inspection.** If requested, two posts shall be furnished for testing purposes from such lots as the engineer may determine.

## SECTION 1045

### PAINT FOR STRUCTURAL STEEL

#### 1045.1 Paint and Paint Material.

**1045.1.1 General.** All single component paints shall be ready-mixed at the factory to comply with the specification formula for the type of paint ordered; shall be well ground to a uniform consistency and smooth texture; shall be free from dirt, water and other foreign matter; shall be of such consistency that they will have good application, covering and leveling properties; and shall dry within the specified period to a good film without running, streaking or sagging. If tinted paint is specified, the tinting material shall be thoroughly and uniformly incorporated within the body of the paint to form a shade which shall match that of a sample submitted for the purpose. Any paint which has livered or in any way hardened or thickened in the container, or in which the pigment has settled out so that the paint cannot be readily broken up with a paddle to a smooth uniform paint of good application consistency, will be rejected. The grinding equipment used in the manufacture of the paint shall meet the approval of the engineer. In no case will the use of a colloid mill, steel ball mill or high speed mill be permitted.

**1045.1.1.1** All percentages and proportions are on a weight (mass) basis unless otherwise stated.

**1045.1.2 Sampling.** Each batch or lot of pigment and vehicle constituents for mixed paints shall be sampled and approved prior to being incorporated into a paint mixture when requested by the Division Engineer, Materials. Each batch or lot of paint shall be sampled and approved prior to use. Each batch or lot of each component of multiple-component paints shall be sampled and approved prior to use.

**1045.1.3 Packaging.** All containers shall be approved by the engineer as to type and weight (mass) and shall be free of physical defects. The lining of the container shall not react with the paint. All containers shall be cleaned of any paint spilled during filling operations. Except when supplied in containers of less than five gallons (19 L), all mixed paint shall be packaged in strong substantial 24 gage (0.6 mm) or heavier, new metal containers having lug-type replaceable tops. They shall bear a label on which shall be clearly shown the name of the manufacturer, the kind of paint, the lot number, date of manufacture and net weight (mass) of contents. The lot number and date of manufacture shall be stamped, stenciled, or painted directly onto the container using a weatherproof, durable material.

**1045.1.3.1** Multiple-component paint shall be packaged in multiple-compartment containers or in separate containers. The components shall be packaged in such proportions that the pigment, mixed with the vehicle and activator, if used, will yield one or five gallons (4 or 19 L) of mixed paint. Each container shall bear a label on which shall be clearly shown the name of the manufacturer or brand name of paint, the lot number, date of manufacture, shelf life and, in the case of organic zinc silicate paint, the individual net weights (masses) of pigment and vehicle. The lot number and date of manufacture shall be stamped, stenciled, or painted directly onto the container using a weatherproof, durable material. The label on the vehicle container shall also include complete instructions for use of the paint.

**1045.1.4 Determination of Quantities.** Quantities of paint shall be determined by volume. One gallon (liter) shall equal 231 cubic inches (0.001 m<sup>3</sup>) at 77 F (25 C).

**1045.2 Inorganic Zinc Silicate Paint.** Inorganic zinc silicate paint shall be a two-component self-curing type which, when mixed, and applied in accordance with the requirements of [Sec 712](#), cures without the use of a separate curing solution, and shall have the properties described herein.

**1045.2.1 Pigment.** The zinc pigment component shall comply with the requirements of ASTM D 520 for Type I.

**1045.2.2 Vehicle.** The vehicle component shall consist primarily of an alkyl silicate in an appropriate alcohol solvent. Total solids, by weight (mass), in the vehicle component shall not be less than 21 nor more than 45 percent. The solids content shall be determined by drying the sample to a constant weight (mass) at 212 F (100 C).

**1045.2.3 Mixed Paint.** Mixed paint shall conform to the following requirements:

(a) The zinc portion shall be at least 85 percent by weight (mass) of the total solids of the dried coating.

(b) The total solids, when heated at 212 F (100 C) for 3 hours, shall be not less than 80 percent by weight (mass).

(c) The paint shall tolerate up to one percent water contamination without gellation.

(d) The usable pot life of the mixed paint shall be not less than 12 hours at 77 F (25 C). There shall be no hard settling which cannot be easily redispersed during this period.

(e) The inorganic zinc coating shall be so formulated as to produce a distinct contrast in color with the blast cleaned metal surfaces and with the vinyl finish coat.

**1045.2.4 Resistance Tests.** Test panels of steel meeting the requirements of ASTM D 609 shall be prepared by cleaning all surfaces to the same degree specified under [Sec 712](#). A 3-mil (76  $\mu$ m) coating (dry thickness) shall then be applied to the test panels in accordance with the manufacturer's current printed instructions. The coating shall be cured as recommended by the manufacturer. Each of the following tests shall be performed on one or more test panels. The material will not be accepted if any individual test panel fails any of the following tests:

(a) Fresh Water Resistance. Panels shall be scribed down to base metal with an X of at least 2-inch (50 mm) legs and shall be immersed in fresh tap water at  $75 \pm 5$  F ( $24 \pm 3$  C). The panels shall show no rusting, blistering, or softening when examined after 30 days.

(b) Salt Water Resistance. Panels shall be scribed down to base metal with an X of at least 2-inch (50 mm) legs and immersed in 5 percent sodium chloride at  $75 \pm 5$  F ( $24 \pm 3$  C). The panels shall show no rusting, blistering, or softening upon examination after 7, 14 and 30 days. The sodium chloride solution shall be replaced with fresh solution after each examination.

(c) Weathering and Salt Fog Resistance. Panels shall be tested in the weatherometer in accordance with ASTM G 23, Type D for 300 hours, beginning the test at the beginning of the wet cycle. After this period the panels shall be removed and scribed with an X of at least 2-inch (50 mm) legs down to base metal. The test panels shall then be tested in accordance with ASTM B 117. After 1000 hours of continuous exposure in the salt spray chamber, the coating shall show no loss of bond, nor shall the coating show rusting or blistering beyond 1/16 inch (1.5 mm) from the center of the scribe mark.



(d) Resistance to Elevated Temperatures and Thermal Shock. Panels shall be exposed to a temperature of 500 F (260 C) for one hour, then quenched immediately in  $65 \pm 5$  F ( $18 \pm 3$  C) water. Panels subjected to this test shall show no blistering or flaking of the coating.

**1045.2.5 Manufacturer and Brand Name Approval for Inorganic Zinc Primer.** Prior to approval and use of inorganic zinc, the manufacturer shall submit in triplicate to the Division Engineer, Materials, a certified test report from an approved independent testing laboratory showing specific test results conforming to all quantitative and resistance test requirements of these specifications. The certified test report shall also contain the exact ratio, by weight (mass), of the pigment component to the vehicle component of the paint used for the tests, the lot tested, the manufacturer's name, brand name of paint, and date of manufacture. Upon approval by the engineer of this certified test report, further resistance tests will not be required, except as hereinafter noted, of that manufacturer for that brand name of paint. New certified test results shall be submitted any time the manufacturing process or the paint formulation is changed, and may be required by the engineer when sampling and testing of material offered for use indicates nonconformance to any of the requirements herein specified.

**1045.3 Blank.**

**1045.4 Blank.**

**1045.5 High Solids Inorganic Zinc Silicate Coating.**

**1045.5.1** High solids inorganic zinc coating shall be a solvent base multiple component material which, when mixed and applied in accordance with the requirements of [Sec 712](#), cures without the use of a separate curing solution. High solids inorganic zinc coating shall comply with the requirements of AASHTO M 300, Type IA, except the volatile organic compounds (VOC) shall not exceed 3.50 pounds/gallon (420 g/L). If thinning is necessary for application, the maximum VOC shall not exceed 3.50 pounds/gallon (420 g/L).

**1045.5.2 Manufacturer and Brand Name Approval for Inorganic Zinc Primer.** Prior to approval and use of high solids inorganic zinc, the manufacturer shall submit to the Division Engineer, Materials, a certified test report from an approved independent testing laboratory showing specific test results conforming to all quantitative and resistance test requirements of these specifications. The certified test report shall also contain the exact ratio, by weight (mass), of each component of the coating used for the tests, the lot tested, the manufacturer's name, brand name of coating and date of manufacture. Upon approval by the engineer of this certified test report, further resistance tests will not be required, except as hereinafter noted, of that manufacturer for that brand name of coating. New certified test results shall be submitted any time the manufacturing process or the coating formulation is changed, and may be required by the engineer when sampling and testing of material offered for use indicates nonconformance to any of the requirements herein specified.

**1045.6 High Solids Epoxy System G Intermediate Coating.**

**1045.6.1** The coating shall be a two-component, modified epoxy primer with an amine/amide type curing system compatible as an intermediate coat over inorganic zinc primer and suitable for topcoating with polyurethane.

**1045.6.2 Pigment.** The pigment shall be a minimum of 43 percent by weight (mass) of the coating.

**1045.6.3 Vehicle.** The vehicle shall be a maximum of 57 percent by weight (mass). The vehicle shall consist of an epoxy resin.

**1045.6.4 Mixed Coating.**

Color - Different from zinc primers to provide a contrast.

Mix Ratio 1:1 by Volume	
Weight (Mass) per Gallon (Liter), lbs (kg), min	10.0 (1.20)
Solids, percent by weight (mass)	
ASTM D 1644 for 72 hours at 100 F (37.8 C) min.	79
Pigment, percent by weight (mass), min.	43
Viscosity, Krebs-Stormer, 77 F (25 C) KU	80-130
Volatile Organic Content*, max., lb/gal (g/L)	3.50 (420)
Fineness of Grind, Hegeman Gage, min.	4
Sag Resistance, Leneta Anti-Sag Meter, mils (µm) wet, min.	8 (203)
Pot Life at 77 F (25 C), hours, min.	6
Dry to Touch, hours, max.	3
Dry to Handle, hours, max.	6

\*Maximum when thinned for application.

**1045.6.5 Manufacturer and Brand Name Approval.** Prior to approval and use of the specified coating system, the manufacturer shall submit to the Division Engineer, Materials, a one-gallon (4 L) sample of the coating proposed. The manufacturer shall also submit a certified test report from an approved independent testing laboratory showing specific test results obtained on the specified coating system for Relative Humidity Resistance ASTM D 1735 or D 2247, 3000 hours, Salt Fog Resistance ASTM B 117, 3000 hours and Accelerated Weathering ASTM G 23 Method 1, Type EH (Carbon Arc), 4000 hours. ASTM G 26, Method 2, Xenon Arc or G 53 QUV (Fluorescent UV-Condensation Type using Type A lamps) may be used as an alternate to Carbon Arc.

**1045.6.5.1** All coats of the system to be tested shall be applied to properly prepared steel test panels. Each coat of the system shall be from the same manufacturer. Test panels for salt fog exposure shall be scribed as described in ASTM D 1654-92 and, when rated according to ASTM D 1654-92, each panel must receive a rating of 7 or greater. No panel tested shall exhibit more than slight rusting, undercutting, discoloration, fading, blistering, chalking, loss of gloss, or change in color. All testing shall be performed on duplicate sets of test panels, and upon completion of the prescribed exposure testing, the manufacturer shall submit one set of the exposed panels to the Division Engineer, Materials.

**1045.6.5.2** The manufacturer shall also provide documentation that the specified coating system has performed satisfactorily for three years. The document shall include the name, address and telephone number of the proprietary agency and location of the structures. Upon approval of the coating by the engineer, further submittals for preliminary approval will not be required of that manufacturer for that brand name of coating, except as hereinafter noted. A new sample shall be submitted any time the manufacturing process or the batching proportions are changed. The engineer may withdraw manufacturer and brand name approval when sampling and testing of material offered for use indicates nonconformance to any of the requirements herein specified. All data submitted for preliminary approval will be considered confidential to MoDOT.

#### 1045.7 Polyurethane System G Finish Coating.

**1045.7.1** The coating shall be a two-component, aliphatic acrylic polyurethane suitable for use over [Sec 1045.6](#), High Solids Epoxy Intermediate Coating. The coating shall cure to a semi-gloss to high gloss, abrasion resistant surface and shall provide an easily cleanable finish.

**1045.7.2 Pigment.** The pigment shall be a minimum of 29 percent for gray and a minimum of 24 percent for brown by weight (mass) of the total coating. The pigment shall consist of titanium dioxide, color retentive tinting pigments, extender pigments and UV stabilizers.

**1045.7.3 Vehicle.** The vehicle shall be a maximum of 71 percent for gray and a maximum of 76 percent for brown by weight (mass) of the total coating. The vehicle shall consist of an aliphatic acrylic polyurethane.

#### 1045.7.4 Mixed Coating.

Color, Federal Standard 595b

	<b>Gray</b> 26373	<b>Brown</b> 30045
Weight (Mass) per Gallon (Liter), lbs (kg), min.	10.0 (1.20)	9.3 (1.14)
Solids, percent by weight (mass) ASTM D 1644 for 72 hours at 100 F (37.8 C), min.	74	71
Solids by Volume, min	63	58
Pigment, percent by weight (mass), min.	29	24
Viscosity, Krebs-Stormer, 77 F (25 C), KU	65-96	65-96
Volatile Organic Content*, lb/gal (g/L), max.	3.50 (420)	3.50 (420)
Fineness of Grind, Hegeman Gage, min.	6	6
Sag Resistance, Leneta Anti-Sag Meter, mils (µm) wet, min.	8 (203)	8 (203)
Pot Life at 74 F (23.9 C), hours, min.	6	6
Dry to Touch, hours, max.	4	4
Dry to Handle, hours, max.	8	8

\*Maximum when thinned for application.

**1045.7.5 Manufacturer and Brand Name Approval.** Manufacturer and brand name approval shall be in accordance with [Sec 1045.6.5](#).

#### 1045.8 Waterborne Acrylic System H Intermediate and Finish Coating.

**1045.8.1** The intermediate coating shall be a single component waterborne acrylic compatible as a coating over inorganic zinc primers.

**1045.8.2** The finish coating shall be a single component waterborne acrylic suitable for use over a waterborne acrylic intermediate coating. The coating shall cure to a tough, abrasion resistant surface which performs well in weathering exposures. The gray finish coat shall cure to a semi-gloss finish, and the brown finish coat shall cure to a low-gloss finish.

**1045.8.3 Pigment.** The pigment shall be a minimum of 18 percent for gray and a minimum of 15 percent for brown by weight (mass) of the total coating. The pigment shall consist of titanium dioxide, color retentive tinting pigments and extender pigment.

**1045.8.4 Vehicle.** The vehicle shall be a maximum of 82 percent for gray and a maximum of 85 percent for brown by weight (mass) of the total coating. The vehicle shall consist of acrylic resin suitable for use in exterior coatings.

**1045.8.5 Mixed Coating.**

Color - Intermediate Coat

Provide a contrast between primer and finish coat.

Color - Finish Coat

Federal Standard 595b

	<b>Gray</b> 26373	<b>Brown</b> 30045
Weight (Mass) per Gallon (Liter), lbs (kg), min.	10.0 (1.20)	9.3 (1.11)
Solids, percent by weight (mass), min.	42	42
Solids, percent by volume, min.	34	34
Pigment, percent by weight (mass), min.	18	15
Percent Non-volatile Vehicle, by weight (mass) of coating, min.	22	28
Viscosity, Krebs-Stormer, 77 F (25 C), KU	80-100	80-100
Volatile Organic Content, lb/gal (g/L), max.	3.50 (420)	3.50 (420)
Fineness of Grind, Hegeman Gage, min.	7	7
Sag Resistance, Leneta Anti-Sag Meter, mils (µm) wet, min.	8 (203)	8 (203)
Dry to Handle, hours, max.	2	2

**1045.8.6 Manufacturer and Brand Name Approval.** Prior to approval and use of waterborne acrylic intermediate and finish coats, the manufacturer shall obtain manufacturer and brand name approval in accordance with [Sec 1045.6.5](#).

## SECTION 1047

### CORRUGATED POLYETHYLENE CULVERT PIPE

**1047.1 Scope.** These specifications cover corrugated polyethylene culvert pipe intended to be used for the construction of culverts.

**1047.2 Material.** Corrugated polyethylene culvert pipe and fittings shall conform to the requirements herein specified and to the requirements of AASHTO M 294. Unless otherwise specified, the pipe may have a full circular cross-section with a corrugated surface both inside and outside or the pipe may have a corrugated surface outside and a smooth inner liner of the same material fused to the inside of the pipe. The pipe shall not be perforated unless otherwise specified. In case of conflict with AASHTO M 294, these specifications shall prevail.

**1047.3 Basis of Acceptance.** Acceptance of polyethylene culvert pipe will be based upon a satisfactory manufacturer's certified analysis and guarantee and pipe identification markings or upon tests on samples of the material or upon both. The frequency of sampling will be determined by the engineer. The manufacturer shall provide equipment and personnel required to obtain samples as directed by the engineer.

**1047.4 Accepted Brands of Polyethylene Pipe.** No polyethylene pipe will be accepted under these specifications until the pipe manufacturer's certified analysis and guarantee has been approved by the engineer. Misbranding or other misrepresentation, and non-uniformity of product, will each be considered a sufficient reason to discontinue the acceptance of any brand under these specifications and notice sent to the manufacturer will be considered to be notice to all companies which handle that particular brand.

**1047.4.1 Pipe Manufacturer's Certified Analysis.** The manufacturer of each brand shall file with the Division Engineer, Materials, a certificate setting forth the name or brand of pipe to be furnished, the specified type, category, grade and class of polyethylene compounds. The certificate shall be sworn to for the manufacturer by a person having legal authority to bind the company. The certified analysis shall have attached a certified test report from an approved independent testing laboratory showing specific results of tests performed on each diameter pipe to be furnished, conforming to all requirements of these specifications. The pipes tested shall be randomly selected for test by the independent testing laboratory as being representative of that manufacturer's pipe.

**1047.4.2 Pipe Manufacturer's Guarantee.** The manufacturer of the pipe shall submit with the certified analysis a guarantee providing that all pipe furnished shall conform to the specification requirements, shall bear a suitable identification brand or mark, and shall be replaced without cost to the Commission when not in conformity with the specified requirements. The guarantee shall be so worded as to remain in effect so long as the manufacturer continues to furnish material. The manufacturer shall make such tests and measurements as necessary to ensure that the material produced complies with all specification requirements. These tests and measurements shall be identified by the identification symbols or code used on the pipe in a manner which will permit the manufacturer to produce specific reports showing test results representative of specific lots of polyethylene pipe. Copies of reports of these tests shall be kept on file and shall be submitted to the engineer upon request. The brand shall be removed or obliterated by the manufacturer on all material where control tests, as outlined herein, do not show conformance to this specification.

**1047.5 Sampling.** Samples of polyethylene pipe will be obtained from fabricated culvert sections in accordance with AASHTO M 294 at a frequency determined by the engineer. Samples may be taken at the point of manufacture, intermediate distribution point, or at the project as determined by the engineer.

**1047.6 Testing.** Testing specimen size and method of test shall be in accordance with AASHTO M 294.

**1047.7 Coupling Bands.** Field joints of corrugated polyethylene pipe shall provide circumferential and longitudinal strength to maintain the pipe alignment, prevent separation of pipe, and prevent infiltration of side fill material. Coupling bands, if used, shall be of the same base material as the pipe. Corrugations in the bands shall have the same configuration as the corrugations in the pipe ends being connected. The design of any field jointing device shall be submitted to the Division Engineer, Materials, for approval prior to use.

**1047.8 Inspection.**

**1047.8.1** The engineer may inspect the fabricated pipe at the manufacturing plant, intermediate distribution point, or project. The engineer shall be furnished by the manufacturer, an itemized statement of the sizes and lengths of pipe in each shipment. The engineer shall have free access to the manufacturing plant or intermediate distribution point for inspection, and every facility shall be extended for this purpose. Any pipe which has been previously rejected and included in a later lot will be considered sufficient cause for rejection of the entire lot. A lot is defined as all the material presented for inspection at one time.

**1047.8.2** Inspection will include an examination of the pipe for markings, deficiency in specified diameter, net length of fabricated pipe, and any evidence of poor workmanship. The inspection may include taking samples.

**1047.9 Rejection.**

**1047.9.1** Any individual section of pipe failing to meet the marking, diameter, length, or workmanship requirements of these specifications will be rejected. If 25 percent of the pipe in any lot fails to meet these requirements, the entire shipment may be rejected.

**1047.9.2** If a pipe fails to meet the requirements for pipe stiffness, pipe flattening, environmental stress cracking or brittleness, the pipe sampled will be rejected and the lot will be resampled. A resample will be of the same size as the original sample. The resample must comply in all respects or the entire shipment will be rejected.

**1047.9.3** Rejections may be cause for discontinuance of acceptance by brand registration and guarantee in which case the manufacturer will be required to provide proof of satisfactory testing of each lot, prior to inspection.

## SECTION 1048

### PAVEMENT MARKING MATERIAL

**1048.1 Scope.** This specification covers preformed pavement marking tape, thermoplastic pavement marking material, preformed removable pavement marking tape and preformed temporary pavement marking tape.

#### **1048.2 Type 1 Preformed Marking Tape.**

**1048.2.1** Type 1 preformed marking tape shall be capable of being laid into new, dense and open graded asphalt wearing surfaces during the final roller operation. After application the tape shall be immediately ready to receive traffic.

**1048.2.2 Composition.** The tape shall consist of a mixture of polymeric material, pigments and glass beads distributed throughout the cross-sectional area with a reflective layer of glass beads embedded in the top surface. The tape shall be sufficiently flexible so as to conform to the roadway without cracking or breaking.

**1048.2.3 Dimensions.** The tape without adhesive shall have a minimum thickness of 60 mils (1.5 mm). A patterned surface is allowable but shall have a minimum thickness of 60 mils (1.5 mm) over at least 50 percent of its surface. The tape shall have a nominal width of 4 inches (100 mm) and the edges shall not be tapered.

**1048.2.4 Adhesive.** The tape shall be supplied with a precoated factory-applied adhesive for immediate application to asphalt pavement without the use of heat, solvent or other adhesive operations. The tape and adhesive shall be of a type that water used on the compaction roller will not be harmful to successful application.

**1048.2.5 Reflectance.** The tape shall be readily visible when exposed to automobile headlights at night and shall have a minimum specific luminance as shown in the following table, expressed as millicandelas per footcandle (lux) per square foot (square meter). The tape shall be applied to an 8 inch by 36 inch (200 x 900 mm) panel in a longitudinal orientation and measured in accordance with MoDOT Test Method T8 at 86 degrees entrance angle.

Observation Angle	White	Yellow
0.2 degree	550	410
0.5 degree	380	250

The reflected color shall be white or yellow as required for the specified application.

**1048.2.6 Approval.** To obtain approval of Type 1 preformed marking tape, the manufacturer shall submit material and application specifications, samples of the tape, and a history of satisfactory use as a pavement marking tape to the engineer for testing and evaluation. The quantity, types and widths of tape submitted shall be at the discretion of the engineer. Following the testing and evaluation, satisfactory tape will be placed on a prequalified list.

**1048.2.6.1** For acceptance on the project, the contractor shall furnish to the engineer a manufacturer's certification in triplicate stating the manufacturer and trade name, and certifying that the material furnished is of the same composition as originally prequalified and in no way has been altered or changed.

### **1048.3 Thermoplastic Marking Material.**

#### **1048.3.1 Thermoplastic Compound.**

**1048.3.1.1** Thermoplastic material shall comply with AASHTO M 249 except material formulated with alkyd resin shall have a maximum specific gravity of 2.35. The pre-mix beads shall be uncoated and shall conform to AASHTO M 247, Type 1.

**1048.3.2 Primer.** Primer, if required, shall be as recommended by the manufacturer of the thermoplastic material.

#### **1048.3.3 Sampling and Testing of Thermoplastic Material.**

**1048.3.3.1** The engineer shall have free access to the material and all facilities for the purpose of inspection. A sample will be taken from each lot of thermoplastic marking material presented for inspection. A lot is defined as 22,000 pounds (10,000 kg), or fraction thereof, presented for inspection at one time regardless of the number of composition batches in the lot. A sample will consist of one 50-pound (23 kg) sample of material packaged in accordance with [Sec 1048.3.5](#). The engineer reserves the right to sample at the point of manufacture, at intermediate points of storage, or at destination.

**1048.3.3.2** The thermoplastic material shall be tested in accordance with AASHTO M 249 and AASHTO T 250, as applicable.

#### **1048.3.4 Certification and Acceptance of Thermoplastic Material.**

**1048.3.4.1** The contractor shall furnish a manufacturer's certification in triplicate to the engineer, for each lot furnished, certifying that the material supplied conform to all requirements specified. The certification shall include or have attached typical results of required tests.

**1048.3.4.2** Acceptance of the material will be based on the manufacturer's certification and upon the results of such tests as may be performed by the engineer.

#### **1048.3.5 Packaging and Marking of Thermoplastic Material.**

**1048.3.5.1** Thermoplastic material may be furnished as blocks approximately 12 x 37 x 2 inches (300 x 950 x 50 mm) or as granular material in bags. Either unit shall weigh (have a mass of) approximately 50 pounds (23 kg).

**1048.3.5.2** Each package shall be labeled or marked with the color of the material, name of the manufacturer, date of manufacture, batch number, type of material (alkyd, hydrocarbon or epoxy), net weight (mass) of contents, and the temperature to which the material shall be heated for application. Granular hydrocarbon and alkyd thermoplastic material may be packaged in thermally degradable bags which are designed to melt with the material, provided the label states the bag does not adversely affect the application or performance of the thermoplastic material.

#### **1048.3.6 Drop-On Glass Beads.**

**1048.3.6.1** The glass beads for drop-on application on the thermoplastic pavement marking material shall be moisture resistant and shall be manufactured from glass of a composition that is highly resistant to traffic wear and to the effects of weathering. The glass beads shall



comply with the requirements of AASHTO M 247, Type 1, including packaging and marking requirements.

#### **1048.3.6.2 Certification and Acceptance of Drop-On Glass Beads.**

**1048.3.6.2.1** The contractor shall furnish a manufacturer's certification in triplicate to the engineer for each lot, certifying the beads conform to all requirements specified. The certification shall include or have attached specific results of tests on each lot furnished for roundness, refractive index, flow characteristics and gradation. The certifications shall show the quantity and lot number.

**1048.3.6.2.2** Acceptance of the beads will be based on the manufacturer's certification and upon the results of such tests as may be performed by the engineer.

#### **1048.4 Preformed Removable Pavement Marking Tape.**

**1048.4.1** Preformed removable tape shall be capable of being removed manually either by hand or with a roll up device and shall leave no objectionable or misleading image after removal.

**1048.4.2 Color.** The tape shall be white or yellow as required for the specific application.

**1048.4.3 Reflectivity.** The tape shall be readily visible when exposed to automobile headlights at night and shall have a minimum specific luminance as shown in the following table, expressed as millicandelas per footcandle (lux) per square foot (square meter). The tape shall be applied to an 8 inch by 36 inch (200 x 900 mm) panel in a longitudinal orientation and measured in accordance with MoDOT Test Method T8 at 86 degrees entrance angle.

<b>Observation Angle</b>	<b>White</b>	<b>Yellow</b>
0.2 degree	1750	1300
0.5 degree	1250	800

The reflected color shall be white or yellow as required for the specified application.

**1048.4.4 Adhesive.** The tape shall have a precoated pressure sensitive adhesive which requires no activation procedures. The adhesive shall be resistant to oil, chemicals, acids, solvents and water.

**1048.4.5 Dimensions.** The tape shall have a minimum thickness of 15 mils (380 µm) and shall have a nominal width of 4 inches (100 mm). Following application, the tape shall remain conformed to the texture of the pavement.

**1048.4.6 Durability.** The tape shall be weather resistant and show no appreciable fading, lifting, or shrinkage during its useful life. Samples of the tape applied to standard specimen plates and tested in accordance with Federal Test Method No. 141, Method 6192, for 1000 cycles, using a CS-17 wheel and 1000-gram load shall not expose the backing material.

**1048.4.7 Appearance.** The tape as applied shall be in good condition, free of cracks and with edges straight and unbroken.

#### **1048.4.8 Approval.**

**1048.4.8.1** Prior to approval and use of preformed removable tape, the manufacturer shall submit material and application specifications and samples of the tape for testing and

evaluation. The quantity, types and widths of tape submitted shall be at the discretion of the engineer. Following the testing and evaluation, satisfactory tape will be placed on a prequalified list.

**1048.4.8.2** Preformed removable tape appearing on the prequalified list may be accepted for use on the basis of brand name, color and width as shown in the prequalified list, so long as satisfactory performance is obtained in the field.

#### **1048.5 Preformed Short Term Pavement Marking Tape.**

**1048.5.1 Color.** The tape shall be white or yellow as required for the specific application.

**1048.5.2 Reflectivity.** The tape shall be readily visible when exposed to automobile headlights at night and shall have a minimum specific luminance as shown in the following table, expressed as millicandelas per footcandle (lux) per square foot (square meter). The tape shall be applied to an 8 inch by 36 inch (200 x 900 mm) panel in a longitudinal orientation and measured in accordance with MoDOT Test Method T8 at 86 degrees entrance angle.

<b>Observation Angle</b>	<b>White</b>	<b>Yellow</b>
0.2 degree	1350	800
0.5 degree	750	500

The reflected color shall be white or yellow as required for the specified application.

**1048.5.3 Adhesive.** The tape shall have a precoated pressure sensitive adhesive which requires no activation procedures. The adhesive shall be resistant to oil, chemicals, acids, solvents and water.

**1048.5.4 Dimensions.** The tape shall have a minimum thickness of 15 mils (380 µm) and shall have a nominal width of 4 inches (100 mm). Following application, the tape shall remain conformed to the texture of the pavement.

**1048.5.5 Durability.** The tape shall be weather resistant and show no appreciable fading, lifting, or shrinkage during its useful life. Samples of the tape applied to standard specimen plates and tested in accordance with Federal Test Method No. 141, Method 6192, for 1000 cycles, using a CS-17 wheel and 1000-gram load shall not expose the backing material.

**1048.5.6 Appearance.** The tape as applied shall be in good condition, free of cracks and with edges straight and unbroken.

#### **1048.5.7 Approval.**

**1048.5.7.1** Prior to approval and use of preformed short term marking tape, the manufacturer shall submit material and application specifications and samples of the tape for testing and evaluation. The quantity and type of tape submitted shall be at the discretion of the engineer. In addition, the manufacturer shall submit a certification stating that the material conforms to all of the requirements of these specifications. Following the testing and evaluation, satisfactory tape will be placed on a prequalified list.

**1048.5.7.2** Preformed short term marking tape appearing on the prequalified list may be accepted on the basis of brand name and color as shown on the prequalified list, so long as satisfactory performance is obtained in the field.

## SECTION 1049

### PRECAST CONCRETE BOX CULVERTS

**1049.1 Description.** These specifications cover precast concrete box culverts.

**1049.2 Material.**

**1049.2.1 Aggregates.** Fine and coarse aggregates for the concrete mixture shall comply with the requirements of [Sec 1005](#) except the requirements for gradation and percent passing the No. 200 (75 µm) sieve shall not apply.

**1049.2.2 Cement.** Cement shall comply with the requirements of [Sec 1019](#).

**1049.2.3 Fly Ash.** Fly ash shall comply with the requirements of [Sec 1018](#).

**1049.2.4 Mixture.** The aggregates shall be sized, graded, proportioned and thoroughly mixed in such proportions of cement and water, as will produce a homogeneous concrete mixture of such quality that the units will conform to the test and design requirements. Admixtures or blends may be used with the approval of the engineer. In no case, however, shall the proportion of portland cement in the mixture be less than 564 pounds per cubic yard (335 kg/m<sup>3</sup>) of concrete. Fly ash may be used to replace cement in accordance with the applicable provisions of [Sec 501](#).

**1049.2.5 Admixtures.** Admixtures may be used with the approval of the engineer.

**1049.3 Design.**

**1049.3.1** Except as otherwise specified herein, the precast concrete box sections for the culvert shall be in accordance with the requirements of AASHTO M 259 for culverts with 2 feet (600 mm) or more cover, or AASHTO M 273 for culverts with less than 2 feet (600 mm) of cover, both subject to HS20 live loading, Table 1.

**1049.3.2** Substituted precast concrete box culvert sections shall be designed for the earth cover shown on the plans for the cast-in-place box culvert and shall be equal in height and cross sectional area or as approved by the engineer.

**1049.3.3** The manufacturer may request approval of modified designs which differ from the designs in AASHTO M 259 or AASHTO M 273. The request for such modified or special designs shall fully describe any deviations from those standards, including a drawing showing wall thickness, concrete design strength, the type, size and placement of reinforcement, and inside or outside dimensions of both of the box sections.

**1049.3.4** The following requirements shall also apply.

**1049.3.4.1** The minimum barrel length for box or end section shall be 2 feet (600 mm).

**1049.3.4.2** End sections may be precast or cast-in-place. If precast, the barrel, floor and wing walls shall be cast as an integral unit. In either case they shall be constructed to the same dimensions, shapes, and with the same reinforcement as shown in the standard plans for cast-in-place culvert.

**1049.3.4.3** Segmented end sections may be provided, but are considered to be a modified design and require approval as such.

**1049.3.4.4** Toe walls shall be provided on both the upstream and downstream ends as shown on the standard plans and may be cast-in-place or precast. Precast toe walls shall be connected to the end section floor.

**1049.4 Manufacture.**

**1049.4.1** Curing shall be in accordance with the applicable provisions of [Sec 1026](#) until the concrete has developed the specified compressive strength.

**1049.4.2** Hot or cold weather concreting and concrete testing equipment shall be in accordance with the applicable provisions of [Sec 703](#).

## SECTION 1050

### LUMBER, TIMBER, PILING, POSTS AND POLES

**1050.1 Scope.** These specifications cover wood products of Southern Pine and Douglas Fir of the West Coast Region as defined in ASTM D 1165.

#### 1050.2 Posts.

**1050.2.1 Posts for Guard Cable.** Posts for guard cable may be round or rectangular as shown on the plans. Round posts shall comply with the applicable requirements of [Sec 1050.2.3](#). Rectangular posts shall be standard rough sawn and of the grade specified in [Sec 1050.2.3.1](#). All posts shall be of the species and pressure-treated as shown in [Table I](#).

**1050.2.2 Posts and Blocks for Guardrail.** Posts and blocks for guardrail shall be rectangular, standard rough sawn and of the size and lengths shown on the plans.

**1050.2.2.1** Post and blocks shall be Douglas Fir or Southern Pine and pressure treated as shown in [Table 1](#). All framing and boring shall be done before treatment. Douglas Fir shall be "Dense No. 1 Structural Grade" conforming to the requirements of Paragraph 131-bb of the current Standard Grading Rules for West Coast Lumber. Southern Pine shall be "No. 1 SR Grade" conforming to the requirements of paragraph 406 of the current Standard Grading Rules for Southern Pine Lumber.

**1050.2.3 Posts for Fence.** Posts for fence shall be round and of the sizes and lengths shown on the plans. They shall be of the species and pressure-treated as shown in [Table I](#). Allowable tolerances for size and length are as follows:

#### ENGLISH

Minimum diameter	(4 inch or smaller)	+1/2 inch, no minus tolerance
	(larger than 4 inch)	+1 inch, no minus tolerance
Length (all diameters)	No limit on over length, minus 1 inch.	

#### METRIC

Minimum diameter	(100 mm or smaller)	+13 mm, no minus tolerance
	(larger than 100 mm)	+25 mm, no minus tolerance
Length (all diameters)	No limit on over length, minus 25 mm.	

**1050.2.3.1 Grade.** Wood for posts shall be sound, free of decay, excessive knots and of end splits and seasoning checks that might affect serviceability. Posts shall also be free of multiple crooks; however, crooks in one plane only, that comply with [Sec 1050.2.3.2](#), will be permitted.

**1050.2.3.2 Straightness.** A straight line drawn from the center of one end of the post to the center of the opposite end shall not deviate from the longitudinal axis of the post at any point more than one percent of the length of the post.

**1050.2.3.3 Manufacture.** Posts shall be clean peeled by mechanical or hand processes, and all bark shall be removed except that strips of inner bark not more than 1/2 inch (13 mm) wide nor more than 3 inches (75 mm) long will be permitted to remain on the peeled post. All protruding knots shall be trimmed flush, and all spurs and splinters shall be removed. The natural taper of round posts shall be followed in machine peeling operation. The ends of all

posts shall be cut square except posts to be driven shall be machine-pointed on the small end prior to treatment.

**1050.2.4 Posts for Signs.** Posts for signs shall be rectangular, rough sawn or surfaced four sides (S4S), with square cut ends, and shall be of the grade, size and length shown on the plans. They shall be of the species and pressure-treated as shown in [Table I](#). If framing and boring is done after pressure treatment, field treatment shall be in accordance with the requirements of [Sec 1050.7](#).

### **1050.3 Lumber and Timber.**

**1050.3.1 Species and Grade Requirements.** Unless otherwise specified, lumber and timber to be used as a permanent part of the structure shall be of the species shown in [Table I](#). The grade to be used will be shown on the plans. Lumber and timber for temporary structures shall be of the species and grades shown on the plans.

**1050.3.2 Dressing Requirements.** Lumber and timber shall be standard rough sawn or shall be surfaced as specified in the contract. Lumber and timber shall be cut to exact lengths or to permissible variations in lengths as shown in the contract.

**1050.3.3 Treatment.** If treatment is specified, lumber and timber shall be pressure-treated as shown in [Table I](#).

### **1050.4 Electric Substation, Service and Span Wire Assembly Poles.**

**1050.4.1** These poles shall be of the length and class specified in the contract, and shall conform to the requirements of ANSI 05.1. They shall be of the species and pressure-treated as shown in [Table I](#). The poles may be gained and drilled in the field after treatment. Areas exposed shall be treated as specified in [Sec 1050.7](#), before cross-arms or equipment are mounted.

**1050.4.2 Pole Crossarms.** The species, grade and treatment of crossarms to be erected on substation and service poles will be shown on the plans.

### **1050.5 Round Timber Piles.**

**1050.5.1** All round timber piles shall conform to the requirements of ASTM D 25, except for size which shall conform to the size requirements of [Table II](#) for the class specified in the contract. Piles for permanent structures shall be clean peeled.

**1050.5.2** Piles to be treated shall be of the species and pressure-treated as shown in [Table I](#). Framing and boring will not be required before treatment. However, exposed untreated areas resulting from framing of treated piling shall be field treated as specified in [Sec 1050.7](#). Untreated piles for use in unexposed locations or in temporary bridges shall be of the species shown in [Table I](#) or of other species approved by the engineer.

### **1050.6 Timber Preservatives.**

**1050.6.1 Creosote.** Creosote shall conform to the requirements of AWP A P1.

**1050.6.2 Pentachlorophenol.** The preservative shall be pentachlorophenol meeting the requirements of AWP A P8 in a hydrocarbon solvent meeting the requirements of AWP A P9, Type A.

**1050.6.3 Ammoniacal Copper Arsenate (ACA) or Chromated Copper Arsenate (CCA).** These preservatives shall comply with the requirements of AWP A P5.

**1050.6.4 Copper Naphthenate For Repair.** This preservative shall be prepared with a solvent conforming to AWP A Standard P9. The preservative concentration shall contain a minimum of 2 percent copper metal.

**1050.6.5 Responsibility for Quality.** Responsibility for using preservatives to meet these specifications shall rest entirely with the contractor, and use of preservatives which fail to meet these requirements will subject the entire charge of material to rejection or to approved retreatment with proper preservative.

**1050.6.6 Final Steaming.** All guardrail, guard cable and sign posts, substation, service and span wire poles, and lumber and timber, except material treated with ACA or CCA, shall be cleaned by a final steam bath in accordance with AWP A C2, C4 or C5 as applicable. In lieu of steam cleaning, sign posts may be strip stacked and air dried for a minimum of 60 days after treatment.

**1050.7 Care After Treatment.** Care shall be taken in handling pressure-treated material. The pressure-treated material shall not be dragged across the ground. Cant hooks, peavies, pickaroons and end cant hooks shall not be used on the side surfaces of treated material. All handling of treated round stock with pointed tools shall be confined to the ends. If the material is accidentally damaged, or framing at site is required, such injuries, cuts, or holes shall be liberally field-treated with two brush coats of preservative of the same type used for the original treatment or of copper naphthenate. The second coat shall be applied after the first coat has been absorbed. Creosote preservative shall be hot when applied. Holes shall be treated by plugging one end and filling with preservative. A bent funnel or other suitable device shall be used for treating horizontal holes.

#### **1050.8 Inspection.**

**1050.8.1** All material shall be rigidly inspected for compliance with these specifications in accordance with AWP A Standard M2.

**1050.8.2** Timber products treated within the state of Missouri or within 100 air miles (160 air kilometers) of the border will be inspected by MoDOT personnel.

**1050.8.3** The inspection of lumber, timber, piling, posts and poles for locations other than shown in [Sec 1050.8.2](#) shall be performed by an approved inspection agency and the cost for inspection shall be borne by the contractor. No direct payment will be made for the cost of inspection, and the cost will be considered as covered under the unit bid price for the specified item.

**1050.8.3.1** An approved inspection agency is defined as a laboratory which has been accredited by the American Lumber Standards Committee, P.O. Box 210, Germantown, MD, or an experienced and qualified testing laboratory approved by the engineer.

**1050.8.3.2** Inspection agencies not accredited by the American Lumber Standards Committee shall submit for approval, to the Division Engineer, Materials, Missouri Department of Transportation, 105 W. Capitol Avenue, P.O. Box 270, Jefferson City, MO 65102, a resume of their agency which shall include a history of inspection of timber and treated products, and a listing of state highway agencies which have approved them and for which they have performed inspection.

**1050.8.4** The contractor shall furnish to the engineer a certification from the supplier stating that the material furnished complies with all requirements of these specifications. The certification shall include or have attached a listing of the material being supplied. Except as noted, the certification shall have attached a certified test report as detailed in Section 7.2 of AWPAs Standard M2 from the inspection agency attesting to complete compliance with these specifications. Electric substation, service and span wire assembly poles do not require the certified test report.

**1050.8.5** Acceptance of the material will be based on satisfactory supplier's and inspection agency certifications and upon results of any tests deemed necessary by the engineer at destination to ascertain compliance with these specifications.



<b>TABLE I</b>						
<b>ENGLISH</b>						
	<b>Species</b>		<b>Type of Preservation and Minimum Retention (Pounds per cubic foot of wood)</b>			<b>Treated in accordance with AWP Specification</b>
	<b>Southern Pine</b>	<b>Douglas Fir</b>	<b>Pentachlorophenol</b>	<b>ACA or CCA</b>	<b>Creosote</b>	
Round Posts for Guard Cable	X		0.50	0.50		C5
Rectangular Posts for Guard Cable	X	X	0.60	0.60		C2
Posts and Blocks for Guardrail	X	X	0.60	0.60		C2
Posts for Fence	X		0.40	0.40	8	C5
Posts for Signs	X	X	0.40	0.40		C2
Lumber and Timber	X	X	0.60	0.60	12	C2
Poles	X		0.38	0.60		C4
Round Timber Piles	X				12	C3
<b>METRIC</b>						
	<b>Species</b>		<b>Type of Preservation and Minimum Retention (kilograms per cubic meters of wood)</b>			<b>Treated in accordance with AWP Specification</b>
	<b>Southern Pine</b>	<b>Douglas Fir</b>	<b>Pentachlorophenol</b>	<b>ACA or CCA</b>	<b>Creosote</b>	
Round Posts for Guard Cable	X		8.0	8.0		C5
Rectangular Posts for Guard Cable	X	X	9.5	9.5		C2
Posts and Blocks for Guardrail	X	X	9.5	9.5		C2
Posts for Fence	X		6.5	6.5	130	C5
Posts for Signs	X	X	6.5	6.5		C2
Lumber and Timber	X	X	9.5	9.5	190	C2
Poles	X		6.0	6.0		C4
Round Timber Piles	X				190	C3

Where more than one species or type of preservative is shown, the contractor shall have the option of furnishing either.

TABLE II																		
ENGLISH																		
Circumferences and Diameters of Timber Piles (in.)																		
Length ft	Class A				Tip		Class B				Tip		Class C				Tip	
	3 ft From Butt						3 ft From Butt						3 ft From Butt					
	Min		Max		Min		Min		Max		Min		Min		Max		Min	
	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia
Up to 50	47	15	57	18	28	9	38	12	63	20	25	8	38	12	63	20	25	8
Over 50	47	15	57	18	25	8	41	13	63	20	22	7	38	12	63	20	22	7
METRIC																		
Circumferences and Diameters of Timber Piles (mm)																		
Length m	Class A				Tip		Class B				Tip		Class C				Tip	
	900 mm From Butt						900 mm From Butt						900 mm From Butt					
	Min		Max		Min		Min		Max		Min		Min		Max		Min	
	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia	Cir	Dia
Up to 15	1200	380	1450	460	710	230	965	305	1600	510	660	200	965	305	1600	510	635	200
Over 15	1200	380	1450	460	630	200	1040	330	1600	510	560	180	965	305	1600	510	560	180

## SECTION 1051

### SLOTTED DRAIN

**1051.1 Scope.** These specifications cover slotted drain.

**1051.2 Pipe.** The pipe portion of the slotted drain shall be 16 gage (1.6 mm) meeting the material and fabrication requirements of [Sec 1020](#). The diameter of the pipe shall be as shown on the plans.

**1051.3 Slotted Drain Grate Assembly.** The grate assembly of Type A, B or C slotted drain shall be fabricated as shown on the plans. The grate assembly shall be 6 inches (150 mm) in height unless otherwise specified on the plans.

**1051.3.1** Type B and Type C slotted drain grate assemblies shall be fabricated from 3/16 inch (4.76 mm) thick AASHTO M 183 structural steel and shall conform to the details in the plans. The entire grate assembly shall be hot dip galvanized, prior to attachment to the pipe, in accordance with AASHTO M 111.

**1051.3.2** Type A slotted drain guide assemblies shall be fabricated from 14 gage (2.0 mm) galvanized steel meeting the same material requirements as the pipe. The drain guide slot shall be assembled with mechanical interlocks requiring no welding.

**1051.4** All coupling devices and other necessary fittings shall comply with the applicable provisions of [Sec 1020](#).

## SECTION 1054

### CONCRETE ADMIXTURES

**1054.1 Scope.** This specification covers air-entraining admixtures, water-reducing admixtures, retarding admixtures, accelerating admixtures and latex emulsion admixtures for concrete.

#### **1054.2 Air-Entraining Admixtures.**

**1054.2.1** Air-entraining admixtures shall conform to the requirements of AASHTO M 154 except as modified herein.

**1054.2.2 Manufacturer's Certification and Guarantee.** The manufacturer shall submit a certification and guarantee to the Division Engineer, Materials, showing the brand name and designation; the composition or description of the admixture; the manufacturing ranges for specific gravity at 77 F (25 C), percent total solids, and pH; the infrared spectrum; the manner in which the material will be identified on containers; and certifying that the material will conform to the requirements of these specifications. The certifications shall include or have attached specific test results as required in [Sec 1054.2.2.1](#) or [1054.2.2.2](#). The manufacturer shall also guarantee that as long as material is furnished under that brand and designation the material will be of the same composition as originally approved and will in no way be altered or changed.

**1054.2.2.1** For an air-entraining admixture other than that specified in [Sec 1054.2.2.2](#) the certification shall include results of tests conforming to the requirements of AASHTO M 154. Tests for bleeding, bond strength and volume change will not be required.

**1054.2.2.2** For an air-entraining admixture which is an aqueous solution of vinsol resin, manufactured by neutralizing the resin with caustic soda (sodium hydroxide), the certification shall include results of tests showing the ratio of sodium hydroxide to vinsol resin, and the percentage of solids based on the residue dried at 105 C. The certification or test report shall also state that no other additive or chemical agent is present in the solution.

**1054.2.3 Approval and Acceptance.** Upon approval of the air-entraining admixture and the manufacturer's certification and guarantee, that brand and designation will be placed on a list of prequalified air-entraining admixtures and will be accepted for use without further certification. If, in actual field use, there is evidence of unsatisfactory results, variability or change in composition or misbranding, the material will be rejected and approval for further use withdrawn until the admixture is again prequalified. Samples of any air-entraining admixture offered for use may be taken at any time considered necessary by the engineer.

**1054.2.4 Packaging and Marking.** The containers in which air-entraining admixtures are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. Bulk shipments shall be accompanied by a delivery ticket showing this information. If the manufacturer supplies air-entraining admixtures in more than one concentration, one concentration shall be designated as standard and others as double strength or triple strength with the containers marked accordingly in letters at least one inch high, or for bulk shipments in a prominent manner on the delivery ticket.

### **1054.3 Water-Reducing Admixtures.**

**1054.3.1** Water-reducing admixtures shall comply with the requirements of AASHTO M 194, Type A, except as modified herein. High range water-reducing admixtures, when permitted for use, shall comply with the requirements of AASHTO M 194, Type F or G.

**1054.3.2 Manufacturer's Certification and Guarantee.** The manufacturer shall submit a certification and guarantee to the Division Engineer, Materials, showing the brand name and designation; the composition or description of the admixture; the manufacturing ranges for specific gravity at 77 F (25 C), percent total solids and pH; the infrared spectrum; the manner in which the material will be identified on containers; and certifying that the material will conform to the requirements of these specifications. The certification shall include or have attached specific test results complying with AASHTO M 194, Type A, F or G as applicable and the recommendation for use including amounts to be added. The manufacturer shall also guarantee that as long as material is furnished under the brand and designation the material will be of the same composition as originally approved and will in no way be altered or changed.

**1054.3.3 Approval and Acceptance.** Upon approval of the water-reducing admixture and the manufacturer's certification and guarantee, that brand and designation will be placed on a list of prequalified water-reducing admixtures and will be accepted for use without further certification. If, in actual field use, there is evidence of unsatisfactory results, variability or change in composition, or misbranding the material will be rejected and approval for further use withdrawn until the material is again prequalified. Samples of any water-reducing admixture offered for use may be taken at any time considered necessary by the engineer.

**1054.3.4 Packaging and Marking.** The containers in which water-reducing admixtures are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. Bulk shipments shall be accompanied by a delivery ticket showing this information.

### **1054.4 Retarding Admixtures.**

**1054.4.1** Retarding admixtures shall conform to the requirements of AASHTO M 194, Type B or D except as modified herein.

**1054.4.2 Manufacturer's Certification and Guarantee.** The manufacturer shall submit a certification and guarantee to the Division Engineer, Materials, showing the brand name and designation; the composition or description of the admixture; the manufacturing ranges for specific gravity at 77 F (25 C), percent total solids and pH; the infrared spectrum; the manner in which the material will be identified on containers; and certifying that the material will conform to the requirements of these specifications. The certification shall include or have attached specific test results complying with AASHTO M 194, Type B or D, and the recommendation for use including amounts to be added. The manufacturer shall also guarantee that as long as material is furnished under that brand and designation the material will be of the same composition as originally approved and will in no way be altered or changed.

**1054.4.3 Approval and Acceptance.** Upon approval of the retarding admixture and the manufacturer's certification and guarantee, that brand and designation will be placed on a list of prequalified retarding admixtures and will be accepted for use without further certification. If, in actual field use, there is evidence of unsatisfactory results, variability or change in composition, or misbranding, the material will be rejected and approval for further use

withdrawn until the material is again prequalified. Samples of any retarding admixture offered for use may be taken at any time considered necessary by the engineer.

**1054.4.4 Packaging and Marking.** The containers in which retarding admixtures are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. Bulk shipments shall be accompanied by a delivery ticket showing this information.

#### **1054.5 Accelerating Admixtures.**

**1054.5.1** Accelerating admixtures shall conform to the requirements of AASHTO M 194, Type C or E, except as modified herein.

**1054.5.2 Manufacturer's Certification and Guarantee.** The manufacturer shall submit a certification and guarantee to the Division Engineer, Materials, showing the brand name and designation; the composition or description of the admixture; the manufacturing ranges for specific gravity at 77 F (25 C), percent total solids and pH; the infrared spectrum; the manner in which the material will be identified on containers; and certifying that the material will conform to the requirements of these specifications. The certification shall include or have attached specific test results complying with AASHTO M 194, Type C or E, and the recommendation for use including amounts to be added. The manufacturer shall also guarantee that as long as material is furnished under that brand and designation the material will be of the same composition as originally approved and will in no way be altered or changed.

**1054.5.3 Approval and Acceptance.** Upon approval of the accelerating admixture and manufacturer's certification and guarantee, that brand and designation will be placed on a list of prequalified accelerating admixtures and will be accepted for use without further certification. If, in actual field use, there is evidence of unsatisfactory results, variability or change in composition or misbranding, the material will be rejected and approval for further use withdrawn until the material is again prequalified. Samples of any accelerating admixture offered for use may be taken at any time considered necessary by the engineer.

**1054.5.4 Packaging and Marking.** The containers in which accelerating admixtures are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. Bulk shipments shall be accompanied by a delivery ticket showing this information.

#### **1054.6 Latex Emulsion Admixtures.**

**1054.6.1** Latex emulsion admixtures shall be non-toxic, film forming, polymeric emulsion in water to which all stabilizers have been added at the point of manufacture. The admixture shall be a styrene-butadiene latex emulsion in which at least 90 percent of the non-volatiles are styrene-butadiene polymers.

**1054.6.1.1** The admixture shall be homogeneous, uniform in composition and shall meet the following requirements when tested in accordance with the procedures shown in Report No. FHWA-RD-78-35, April 1978, Styrene-Butadiene Latex Modifiers for Bridge Deck Overlay Concrete.

Property	Specific Value
Color	White
Polymer Type	Styrene-Butadiene
Percent Solids	46 - 53
pH	5.0 - 12.0, the pH may not vary more than $\pm 1$ from the pH of material submitted for prequalification.
Particle Size	1400 to 2500 Angstroms, the mean particle size shall not vary more than $\pm 300$ Angstroms from the mean diameter of material submitted for the prequalification.
Viscosity	$\pm 20$ centipoises of the viscosity of material submitted for prequalification.
Percent Coagulum	0.10 percent by weight (mass), max.
Freeze-Thaw Stability	0.10 percent by weight (mass) max. coagulum after 2 freeze-thaw cycles.
Surface Tension	50.0 dynes/cm, max.
Percent Butadiene	30 to 40 by weight (mass)

**1054.6.2 Manufacturer and Brand Name Approval.** The manufacturer shall submit a certification and guarantee to the Division Engineer, Materials, showing the brand name and designation; the composition or description of the admixture; the manufacturing ranges for specific gravity at 77 F (25 C), percent total solids and pH; the infrared spectrum; the manner in which the material will be identified on containers; and certifying that the material will conform to the requirements of these specifications. The certification shall include or have attached specific test results complying with this specification. The manufacturer shall also guarantee that as long as material is furnished under that brand and designation the material will be of the same composition as originally approved and will in no way be altered or changed.

**1054.6.3 Approval and Acceptance.** Upon approval of the latex emulsion admixture and manufacturer's certification and guarantee, that brand and designation will be placed on a list of prequalified latex emulsion admixtures and will be accepted for use without further certification. If, in actual field use, there is evidence of unsatisfactory results, variability or change in composition or misbranding, the material will be rejected and approval for further use withdrawn until the material is again prequalified. Samples of latex emulsion admixture offered for use may be taken at any time considered necessary by the engineer.

**1054.6.3.1** For field use, the contractor shall submit a manufacturer's test report for each batch of latex admixture to the engineer. The test report shall show batch identification and shall be prepared, dated and signed by the manufacturer's representative responsible for performing the tests. The test report shall contain specific test results of the properties specified herein.

**1054.6.4 Packaging and Marking.** The containers in which latex emulsion admixtures are delivered shall be plainly marked with the manufacturer's name, the brand name and designation of the material, lot number and net quantity. Bulk shipments shall be accompanied by a delivery ticket showing this information.

## SECTION 1055

### CONCRETE CURING MATERIAL

**1055.1 Scope.** These specifications cover liquid membrane-forming compounds, waterproof paper, polyethylene sheeting, white burlap-polyethylene sheeting, burlap and mats of jute or cotton for curing concrete.

**1055.2 Liquid Membrane-Forming Compounds.** Liquid membrane-forming compounds shall conform to the requirements of AASHTO M 148 for Type 1-D, clear or translucent with fugitive dye, or Type 2, white pigmented, curing compounds. The vehicle shall be Class A.

**1055.2.1 Manufacturer's Certification and Guarantee for White Pigmented Curing Compound.** The manufacturer shall submit a certification and guarantee to the Division Engineer, Materials, setting forth the brand name and designation, the composition or description of the curing material, and the manner in which the material will be identified on the containers. The manufacturer shall further certify that the material conforms to the requirements of these specifications and shall list typical values of current tests for consistency, drying time, reflectance and moisture retention. The manufacturer shall also guarantee that as long as material is furnished under that brand and designation, the material will be of the same composition as that originally approved, and in no way will be altered or changed.

**1055.2.2 Sampling.** Each lot or batch of liquid membrane-forming compound shall be sampled, tested and approved prior to use.

**1055.3 Waterproof Paper.** Waterproof paper shall comply with the requirements of AASHTO M 171.

**1055.4 Polyethylene Sheeting.** Polyethylene sheeting shall comply with the requirements of [Sec 1058](#) for curing portland cement concrete.

**1055.5 White Burlap-Polyethylene Sheeting.** White burlap-polyethylene sheeting shall conform to the requirements of AASHTO M 171.

**1055.6 Burlap and Mats of Jute or Cotton.** Burlap shall be fabric made from jute or other suitable fibers. Jute mats shall consist of two plies of burlap stitched together to maintain the shape and stability of the unit. Cotton mats shall consist of filler or cotton batts covered with unsized cloth or burlap, and tufted or stitched to maintain the shape and stability of the unit. Burlap and mats shall, in the judgment of the engineer, be of such construction and in such condition as required to adequately maintain free moisture on the surface of the concrete with the type of system being used to provide the water. Material shall be free from deleterious matter harmful to concrete.



## SECTION 1056

### RED CONCRETE TINTING MATERIAL

**1056.1 Red Concrete Tinting Material.** This material shall consist of an intimate mixture of iron aggregate and red mineral oxide pigment of an approved tint with such other additives as are deemed necessary by the manufacturer. The tinting material shall contain 7.0 to 10.0 percent red oxide pigment. The material shall be free from oil, grease, dirt and nonferrous particles. The tinting material shall not contain any material which might promote oxidation of the iron particles when exposed to air and moisture, or which might have any detrimental effect on concrete. The iron aggregate portion of the tinting material shall conform to the following requirements:

	<b>Percent by Weight (Mass)</b>
Passing No. 8 (2.36 mm) sieve	95 - 100
Passing No. 16 (1.18 mm) sieve	65 - 87
Passing No. 30 (600 $\mu$ m) sieve	30 - 60
Passing No. 50 (300 $\mu$ m) sieve	0 - 20
Passing No. 100 (150 $\mu$ m) sieve	0 - 5

## SECTION 1057

### MATERIAL FOR JOINTS

**1057.1 Scope.** This specification covers joint material to be used as specified elsewhere in the specifications or as designated on the plans.

**1057.1.1 Dowel Bars.** Dowels for transverse joints shall meet the requirements for Plain Rounds of AASHTO M 31, AASHTO M 42 or AASHTO M 53. They shall be epoxy coated in accordance with [Sec 1036](#) except the coating thickness shall be 5 mils (127  $\mu$ m) minimum, the flexibility of coating requirement will not apply and the cut ends are not required to be coated. They shall be free of cutting burrs and other projections. The free end of the dowel bar for a length of at least 11 inches (280 mm) shall be coated with an approved graphite grease. Graphite grease shall contain a minimum of 25 percent graphite and shall be certified to by the manufacturer or shown on the container label. The graphite grease shall be applied in a manner that will result in a thorough covering of that section of the bar with a thin uniform coating. Dowel supporting units shall conform to one of the types shown on the plans.

**1057.1.2 Tie Bars.** Tie bars for longitudinal joints and construction joints shall be round, deformed and shall meet the requirements of AASHTO M 31, AASHTO M 42 or AASHTO M 53, except that tie bars which are to be bent and straightened shall conform to the requirements of AASHTO M 31, Grade 40. They shall be epoxy coated in accordance with [Sec 1036](#) except the coating thickness shall be 5 mils (127  $\mu$ m) minimum, the flexibility of coating requirement will not apply and the cut ends are not required to be coated.

**1057.1.3 Concrete Joint Sealer, Hot-Poured Elastic Type.** The sealer material shall conform to the requirements of AASHTO M 173, together with the additional requirements and modifications contained herein.

**1057.1.3.1 Physical Properties.** The sealer material shall conform to the following requirements:

Penetration at 77 F (25 C), 150 g, 5 sec	50 - 90
Flow at 140 F (60 C), 75 degree angle, 5 hr, cm	0 - 1.0
Bond at 9 F (-18 C), 100 percent extension, 5 cycles	Pass all 3
Resilience, percent recovery, min	25

The sealer material may be subjected to any or all of the above tests after prolonged heating of the material for 6 hours with constant mixing in a laboratory melter at the manufacturer's recommended pouring temperature. After such heating, the material shall meet the above specified requirements.

**1057.1.3.2 Packing and Marking.** The joint sealer material shall be packed and shipped in suitable commercial containers clearly marked with the name of the material, the name of the manufacturer, brand name, weight (mass), batch number, pouring temperature recommended by the manufacturer, and maximum safe heating temperature.

### 1057.1.3.3 Methods of Test.

Flow	AASHTO T 187
Penetration, Use 6 ounce (170 g) can	AASHTO T 187
Bond, Resilience	MoDOT Test Methods T2 and T9

**1057.1.4 Preformed Fiber Expansion Joint Filler.** This material shall conform to the requirements of AASHTO M 213.

### 1057.2 Joints for Concrete Structures.

#### 1057.2.1 Plastic Waterstop.

**1057.2.1.1 Material Requirements.** Plastic waterstop shall consist of a basic resin of polyvinyl chloride (PVC) with additional resins, plasticizers and stabilizers as necessary to produce a durable material with a high fatigue point, resistant to acid and alkali solutions, showing little deterioration under accelerated aging tests, and shall meet the approval of the engineer. The plastic waterstop shall have a tensile strength of not less than 1800 pounds per square inch (12 MPa), and an ultimate elongation of not less than 200 percent.

**1057.2.1.2 Manufacture.** The waterstop shall be a continuous strip, ribbed on both sides, and with a hollow bulb center, a "U" shaped reinforced center-pleat section, or other approved type of center section.

**1057.2.1.3 Certification.** The contractor shall furnish a manufacturer's certification in triplicate, showing typical test results representative of the material and certifying that the material supplied conforms to the requirements specified.

#### 1057.2.2 Rubber Waterstop.

**1057.2.2.1 Material Requirements.** Rubber waterstop shall consist of a durable, elastic, cured rubber compound capable of effectively sealing joints in concrete against the infiltration of moisture. The rubber waterstop shall meet the following requirements:

Hardness - The Shore A durometer hardness shall be 60 - 70.

Elongation - The elongation shall be not less than 450 percent.

Tensile Strength - The tensile strength shall be not less than 3000 pounds per square inch (20 MPa).

Water Absorption - The water absorption shall be a maximum of 5 percent by weight (mass) after immersion in water for two days at 158 F (70 C).

Tensile Strength After Aging - The tensile strength of the test specimen, after accelerated aging test of seven days at 158 F (70 C), shall be not less than 80 percent of the tensile strength prior to the aging test. The tensile strength of the test specimen, after accelerated aging test of 48 hours in oxygen at 158 F (70 C) and 300 pounds per square inch (2 MPa), shall be not less than 80 percent of the tensile strength prior to the test.

Compression Set - The compression set after 22 hours at 158 F (70 C) shall be not more than 30 percent.

Specific Gravity - The specific gravity shall be 1.17 plus or minus 0.03.

**1057.2.2.2 Manufacture.** The waterstop shall be manufactured in such manner that the finished product will have an integral cross section which will be dense, homogeneous, and free from porosity and other imperfections. Minor surface defects such as surface peel covering less than one square inch (645 mm<sup>2</sup>), and surface cavities or bumps less than 1/4 inch (6 mm) in the longest lateral dimension and less than 1/16 inch (1.5 mm) deep, will be acceptable.

**1057.2.2.3 Certification.** The contractor shall furnish a manufacturer's certification in triplicate, showing typical test results representative of the material and certifying that the material supplied conforms to all of the requirements specified.

**1057.2.3 Copper Sheeting for Flashing.** Copper sheeting shall be of soft grade containing not less than 99.7 percent copper, and shall stand being bent cold through an angle of 180 degrees flat upon itself without cracking on the outside of the bent portion. Test specimens shall have an elongation in 2 inches (50 mm) of not less than 20 percent. The weight per square foot (mass per square meter) of the sheeting to be used will be shown on the plans. Tolerances in thickness shall conform to ASTM B 248.

**1057.2.4 Preformed Sponge Rubber Expansion and Partition Joint Filler.** This material shall conform to the requirements of AASHTO M 153, Type I, Sponge Rubber, except that extrusion not to exceed 0.40 inch (10 mm) will be permitted for material exceeding one inch thick (25 mm). The sponge rubber may be black, light gray to grayish-buff or greenish-buff in color.

**1057.2.5 Preformed Fiber Expansion Joint Material.** This material shall conform to the requirements of AASHTO M 213.

**1057.2.6 Concrete Joint Sealer, Hot-Poured Elastic Type.** The sealer material shall conform to the requirements of [Sec 1057.1.3](#).

**1057.3 Plastic Joint Compound for Vitrified Clay and Concrete Pipe.** This compound shall be a homogeneous blend of bituminous or butyl rubber material, inert filler and suitable solvents or plasticizing compounds thoroughly mixed at the factory to a uniform consistency suitable for sealing joints of vitrified clay and concrete pipe. The compound shall conform to the following requirements:

Bitumen, soluble in CS <sub>2</sub> or Butyl Rubber (Hydrocarbon Blend), ASTM D 482 with 1200 F (649 C) max test temperature, percent by weight (mass), min	45
Ash, percent by weight (mass)	15 - 50
Penetration, standard cone, 150 g, 5 sec, 25 C - use 12 ounce (340 g) can	
Trowel grade, bulk type	110 - 250
Extruded rope or flat tape type	50 - 120

The above penetration ranges include test tolerances. Primer, as recommended by the manufacturer, shall be used with extruded rope or flat tape types, if required to maintain the material in position while pipe sections are being joined.

**1057.4 Tubular Joint Seal.** Tubular joint seal shall be manufactured from extruded closed-cellular rubber, the base polymer being a blend of nitrile and vinyl meeting the physical requirements of ASTM D 1056, Type 2, Class C, Grade 1, and meeting the chemical resistance requirements of AASHTO M 198.

**1057.4.1** The seal shall be a single continuous part conforming to the joint shape. The outer surface shall be completely covered with a natural skin. The cross-sectional diameter and installation shall be in accordance with the manufacturer's recommendations for the size of pipe being placed.

## SECTION 1058

### POLYETHYLENE SHEETING

**1058.1 Scope.** These specifications cover polyethylene sheeting for uses in highway construction.

**1058.2** Polyethylene sheeting for curing portland cement concrete shall be white and shall conform to all requirements of AASHTO M 171.

**1058.3** Polyethylene sheeting for use as a bond breaker under bridge approach slabs shall have a minimum nominal thickness of 4.0 mils (0.10 mm) and a plain surface finish. The sheeting may be natural, clear, white or color tinted with a light color, however black or other dark colors shall not be used. The polyethylene sheeting shall conform to the requirements of either AASHTO M 171 or ASTM D 4397, except the following properties are not required:

- (a) Reflectance requirements, AASHTO M 171 and ASTM D 4397
- (b) Moisture loss requirements, AASHTO M 171
- (c) Water vapor transmission requirements, ASTM D 4397
- (d) Luminous transmittance requirements, ASTM D 4397
- (e) Minimum net weight (mass) requirements, ASTM D 4397

**1058.4 Certification and Acceptance.** The contractor shall furnish a manufacturer's certification that the material supplied conforms to the requirements specified.

## SECTION 1060

### ELECTRICAL CONDUIT

**1060.1 Rigid Metallic Conduit and Tubing.** This specification covers (1) zinc coated rigid steel conduit, (2) intermediate metal conduit, (3) rigid aluminum conduit, (4) zinc coated electrical metallic tubing and (5) fittings for rigid metal conduit, intermediate metal conduit and electrical metallic tubing.

**1060.1.1 Rigid Steel Conduit, Zinc Coated.** This material shall conform to the requirements of ANSI C80.1, except the conduit shall be galvanized on both the inside and the outside surfaces by the hot-dip process. The weight (mass) of zinc coating shall be not less than 0.5 ounce per square foot ( $0.15 \text{ kg/m}^2$ ) of actual coated surface determined in accordance with AASHTO T 65. The zinc coating shall meet the requirements for ductility regardless of the time of manufacture of the conduit. The interior or exterior surfaces or both, may be given a coating of suitable material to facilitate installation of wires and cables and to permit the conduit to be readily distinguished from pipe used for other than electrical purposes.

**1060.1.2 Intermediate Metal Conduit.** This material shall conform to the requirements of UL 1242. The exterior surface shall be galvanized. The weight (mass) of zinc coating shall be not less than 0.5 ounce per square foot ( $0.15 \text{ kg/m}^2$ ) of actual coated surface determined in accordance with AASHTO T 65. The zinc coating shall meet the ANSI C80.1 requirements for ductility. The interior surface shall be coated in accordance with UL 1242. The interior and exterior surfaces, or both, may be given a coating of suitable material to facilitate installation of wires and cables and to permit the conduit to be readily distinguished from pipe used for other than electrical purposes.

**1060.1.3 Rigid Aluminum Conduit.** This material shall conform to the requirements of ANSI C80.5.

**1060.1.4 Electrical Metallic Tubing, Zinc Coated.** This material shall conform to the requirements of ANSI C80.3 except the weight (mass) of zinc coating shall be not less than 0.5 ounce per square foot ( $0.15 \text{ kg/m}^2$ ) of coated surface, as determined in accordance with AASHTO T 65. The zinc coating shall meet the requirements for ductility regardless of the time of manufacture of the tubing.

**1060.1.5 Fittings for Rigid Metal Conduit and Electrical Metallic Tubing.** Fittings shall conform to the requirements of ANSI C80.4.

**1060.1.6 Fittings for Intermediate Metal Conduit.** Fittings shall conform to the requirements of UL 1242, except the coating shall meet the same requirements as the conduit with which the fittings are used.

**1060.1.7 Inspection.** Conduit, tubing and fittings will be inspected for compliance with the specifications, and any desired samples will be taken at either the project location or warehouse, at the option of the engineer. Test specimens for determination of weight (mass) of coating will be not less than 2 inches (50 mm) long, cut not less than 6 inches (150 mm) from the end of the length of conduit or tubing selected for testing. If the prescribed two additional samples for retests are taken, and either does not comply, the lot represented will be rejected.

**1060.1.8 Certifications.** If requested by the engineer, the contractor shall furnish a manufacturer's certification in triplicate, showing typical test results representative of the material, and certifying that the material supplied conforms to all of the requirements specified.

**1060.2 Rigid Nonmetallic Conduit.** Rigid nonmetallic conduit shall be made of either polyvinyl chloride (PVC) or heavy duty polyethylene (PE).

**1060.2.1 PVC Conduit.** PVC conduit, bends, couplings and fittings shall conform to the requirements of Underwriters Laboratories Standard UL 651.

**1060.2.2 Heavy Duty PE Conduit.** Heavy duty PE conduit shall conform to the requirements of ASTM D 3035 SDR11.

**1060.2.3 Inspection.** The material will be inspected for compliance with the specifications, and desired samples will be taken at either the project location or warehouse, at the option of the engineer.

**1060.2.4 Certification.** The contractor shall furnish a manufacturer's certification, in triplicate, certifying that the material supplied conforms to all the requirements specified. If requested by the engineer, the contractor shall also furnish typical test results representative of the material.



## SECTION 1061

### ELECTRICAL CONDUCTORS

**1061.1 Scope.** These specifications cover electrical conductors and associated material for use on highway construction projects. Items furnished shall be new stock unless contract provisions state otherwise. Electrical conductors and associated equipment shall conform to the requirements of ICEA, IMSA, NEMA, RETMA, NEC and the regulations of the National Board of Fire Underwriters, as applicable, and shall meet the approval of the engineer.

**1061.2 Conductors.** Except as noted, all conductors shall be soft drawn, Class B or C stranded copper meeting requirements of ICEA S-6-402, Part 2. Solid conductors may be used only for grounding where connected to a ground rod.

**1061.3 Power Cable, High Voltage.** The voltage rating of the power cable supplying primary electrical power shall be 5 KV for primary voltages less than 5000 volts, and 15 KV for voltages of 5000 volts and above. The specific type of cable shall be as recommended and approved by the utility company or municipality supplying power.

**1061.4 Power Cable, Low Voltage.** Power cable shall be 600-volt, single conductor cable and thermoplastic or thermosetting polyethylene insulated. All cable shall be plainly marked on the outside with the manufacturer's name and identification in accordance with industry practice.

Insulation type shall be THW, RHH, RHW, RHW-2 or USE. Average thickness of insulation shall not be less than specified in the following table with a minimum thickness of 90 percent thereof.

AWG No.	Thickness, Mils (mm)
14-10	45 (1.14)
8-2	60 (1.52)
1-4/0	80 (2.03)
213-500	95 (2.41)
501-1000	110 (2.79)

**1061.5 Cable-Conduit.** Cable-conduit shall consist of one to four low voltage power cables with an insulated sized electrical neutral and a bare safety ground, factory installed in black polyethylene conduit intended for direct burial in the ground. The conduit shall be plainly marked on the outside with manufacturer's name and identification in accordance with industry practice and shall meet the requirements of ASTM D 3485. Cable-conduit shall be accompanied by the manufacturer's certifications in triplicate certifying that the conduit meets the requirements of this specification.

**1061.6 Pole and Bracket Cable.** Pole and bracket cable, located in the lighting or signal pole, or in the sign truss and sign support post, which supplies electrical power to highway lighting and sign lighting fixtures, shall consist of two single conductors. Wire size shall be No. 10 AWG (6 mm<sup>2</sup>) meeting requirements of low voltage power cable. Insulation type shall be THW, THHW, RHH, RHW, RHW-2, USE or UF. Average insulation shall not be less than 45 mils (1.14 mm).

**1061.7 Multi-Conductor Cable.** Multi-conductor cable for traffic signals shall be No. 12 AWG (4 mm<sup>2</sup>) rated at 600 volts and plainly marked on the outside with the manufacturer's name and identification of cable type. Insulation and sheathing shall meet the following requirements:

(a) Insulation of individual conductors shall have a thickness of not less than 30 mils (0.76 mm), of which not less than 20 mils (0.51 mm) shall be polyethylene (PE). The remaining thickness shall be either polyvinyl chloride or extruded nylon. Polyethylene (PE) insulating compound, before application to the conductors, shall be heat-stabilized, have a melt index range of 0.2 to 0.4, and shall comply with the requirements of ASTM D 1248, Type 1, Class A or B, Grade 4 or 5. The insulation shall be applied directly to and shall tightly fit the surface of the conductor. After application, the insulation shall meet the requirements of ICEA S-61-402, Sec 3.9. Polyvinyl chloride (PVC) used for insulation shall comply with the requirements of ICEA S-61-402, Sec 4.3.1.

(b) Sheathing for insulated conductors shall be polyvinyl chloride (PVC) compound meeting the requirements of ICEA S-61-402, Sec 4.3.1.

(c) The average thickness of insulation on each conductor shall not be less than 30 mils (0.76 mm) with a minimum of 27 mils (0.69 mm). The average thickness of the sheath on each multi-conductor cable shall be as specified with a minimum thickness of 80 percent thereof. The outside diameter of signal cable shall not exceed that shown in the following table:

No. of Conductors	Thickness of Sheath Mils (mm)	Maximum Outside Diameter Inch (mm)
2	45 (1.14)	0.46 (11.68)
5	45 (1.14)	0.62 (15.75)
7	60 (1.52)	0.67 (17.02)
12	60 (1.52)	0.87 (22.10)

(d) Crimp-on lugs of an approved type shall be used for all terminal connections of stranded copper conductors in signal heads and terminal compartments.

(e) Color coding for identification of the conductors making up the cable shall be in accordance with ICEA S-61-402, Sec 5.6.3.1.1, Method 1-Colored Compounds with Tracers.

**1061.8 Induction Loop Detector Conductor.** Induction loop detector conductor shall be No. 14 AWG (2.5 mm<sup>2</sup>) minimum, soft drawn, stranded copper wire, with Type XHHW insulation and encased in a 1/4 inch (6 mm) polyvinyl chloride or medium density polyethylene duct.

**1061.9 Loop Detector Lead-In Cable.** Lead-in cable used between the detector and the controller shall be two-conductor, twisted, shielded No. 14 AWG (2.5 mm<sup>2</sup>), soft drawn, stranded copper wire. This cable shall comply with the requirements of IMSA Spec No. 50-2.

**1061.10 Certification.** All cables and conductors shall be accompanied by a certification from the supplier indicating that: (1) the supplier is familiar with the requirements of these specifications and, (2) cable furnished was from a lot manufactured by \_\_\_\_\_ (manufacturer's name) \_\_\_\_\_ whose test results indicate compliance with the specifications.

## SECTION 1062

### PULL AND JUNCTION BOXES

**1062.1 Scope.** These specifications cover pull and junction boxes intended for use on highway lighting, traffic signal and sign lighting projects.

**1062.2 Pull Boxes.** Pull boxes may be cast-in-place concrete, precast concrete, preformed polyester resin mortar or resin mortar and fiberglass. Each pull box shall be equipped with a bolt down cover. The threaded hole which receives the cover hold-down bolt shall be open at the bottom to allow cleanout of sand, dirt and other debris. Covers for pull boxes to be used for highway lighting or sign lighting shall be embossed with "STATE LIGHTING". Covers for pull boxes to be used for traffic signals, or a combination of traffic signals and 120 volt intersection lighting, shall be embossed with "STATE SIGNALS". Lock down bolts shall be stainless steel or brass with a penta-head. Pull box dimensions shall be as shown on the plans.

**1062.2.1** Cast-in-place concrete pull boxes shall be constructed of Class B or B-1 concrete, or a commercial mixture meeting the requirements of [Sec 501](#). Material, proportioning, mixing, slump and transporting of concrete shall be in accordance with applicable provisions of [Sec 501](#). Placing, finishing and curing shall be in accordance with applicable provisions of [Sec 703](#). The pull boxes shall be cast in a neat and workmanlike manner. Forms will be required for the inside surfaces of the pull box walls. If the excavation is irregular, forms will also be required for the outside surfaces of the walls. An outside form shall be installed across all trenches leading into the pull box excavation. The ends of all conduit through the walls shall fit tightly against the inside form.

**1062.2.2** Precast concrete pull boxes shall be constructed of Class B or B-1 concrete, or a commercial mixture meeting the requirements of [Sec 501](#). Material, proportioning, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#). Concrete for precast pull boxes shall be placed, finished and cured in accordance with applicable provisions of [Sec 703](#).

**1062.2.3** Concrete pull box frames and covers shall be cast iron conforming to the requirements of AASHTO M 105, Class 30, and of the dimensions and weights (masses) shown on the plans. Cable hooks shall be galvanized steel or brass with a minimum diameter of 3/8 inch (9.5 mm) and a minimum length of 5 inches (125 mm).

**1062.2.4** Preformed pull boxes shall be composed of mortar consisting of sand, gravel and polyester resin reinforced by a woven glass fiber mat or of resin mortar and fiberglass. The pull box shall withstand a wheel load of 20,000 pounds (9000 kg). Each pull box shall be equipped with a bolt down cover of the same material. Metal conduits, if used in preformed pull boxes, shall be electrically bonded to one another inside each pull box.

**1062.3 Junction Boxes.** Junction boxes shall be flanged and designed for flush mounting if encased in concrete, or designed for surface mounting if external mounting is specified. Junction boxes shall be installed so that covers are removable. Junction boxes shall be watertight NEMA 4 enclosures. They shall be stainless steel or PVC. PVC boxes shall have a minimum wall thickness of 1/4 inch (6 mm). Junction boxes shall conform to the following minimum sizes unless otherwise specified:

<b>Maximum Entering Conduit Size, Inches (mm)</b>	<b>Minimum Box Size, Inches (mm)</b>
2 (50)	12 x 12 x 4 (300 x 300 x 100)
4 (100)	16 x 12 x 6 (400 x 300 x 150)

**1062.3.1** PVC conduit shall be joined to junction boxes using a threaded terminal adapter, a locknut and a sealing washer or "O" ring to make a rigid and waterproof connection. Metal conduit shall be joined to junction boxes using sealing nuts or fittings with sealing washers to make a rigid and waterproof connection. If metal conduit is used, an insulated bushing shall be provided at the end of the metal conduit on the inside of the junction box to prevent scuffing of the cable insulation. The junction box cover shall be made watertight with a suitable gasket and secured with stainless steel or cadmium plated screws or bolts.

## SECTION 1063

### TRAFFIC CONTROL MATERIAL

**1063.1 Scope.** These specifications cover material to be used for traffic control.

**1063.2 Flexible Non-Metallic Drum-Like Channelizers.**

**1063.2.1 Channelizer.** Channelizers shall be manufactured from a plastic polymer, plastic copolymer, rubber elastomer, or any other non-metallic material compounded to meet the requirements of this specification. The channelizer shall be a two-piece (barrel portion and ballast portion), closed top, breakaway design capable of being securely fastened together in such a manner as to prevent accidental separation from air turbulence created by such things as passing trucks or normal winds, but capable of separating if struck by a vehicle. Channelizer seams shall be equal in strength to the rest of the channelizer. Channelizers shall exhibit good workmanship and shall be free of objectionable marks or defects which affect appearance or serviceability.

**1063.2.1.1** The barrel portion shall be pigmented and molded of a Highway Orange color throughout and stabilized against fading by ultra-violet or other light rays by the incorporation of adequate inhibitors. The channelizer shall be circular in shape, approximately 36 inches (900 mm) high, and a minimum of 18 inches (450 mm) in diameter at the narrowest point. The top surface of the channelizer, including any recessed areas, shall be designed to drain. The brand name or model number shall be permanently embossed and clearly visible on each channelizer for identification.

**1063.2.1.2** The ballast portion shall consist of loosely filled sand bags or loosely shoveled sand stored in an interior base, a high density, flexible interior base or a flat exterior-mounted flexible ring base not exceeding 36 inches (900 mm) outside diameter and resting on the ground when installed on the barrel. The ballast portion shall be self draining and installed in such a manner that it will not become a projectile upon impact. The weight (mass) of the ballast shall not exceed 50 pounds (23 kg). The ballast portion shall be low enough to allow a vehicle to pass over the ballast portion without making contact with the undercarriage.

**1063.2.2 Reflective Marking.** The reflective markings shall be horizontal, circumferential, alternating orange and white stripes 4 to 8 inches (100 to 200 mm) wide with the top stripe being orange. The stripes shall be made of Type 2 reflective sheeting meeting the requirements of [Sec 1042](#), unless otherwise noted on the plans, and designed for use on flexible channelizers. There shall be at least two orange and two white stripes on each channelizer laid out in accordance with Section 6C-6 of the Manual on Uniform Traffic Control Devices as shown on the plans. Non-reflectorized spaces between the horizontal orange and white stripes shall be no more than 2 inches (50 mm) wide.

**1063.2.3 Approval and Prequalification.** Prior to approval and use of flexible non-metallic drum-like channelizers, the following requirements shall be met.

**1063.2.3.1** The channelizer supplier shall submit to the Division Engineer, Materials, a manufacturer's certification stating that the channelizer conforms to all of the applicable requirements of these specifications. The certification shall include the brand name or model number, channelizer dimensions, and the number and width of stripes for each color of reflective sheeting. The certification shall also state that:

(a) Two randomly selected channelizers representative of those to be used on MoDOT projects were subjected to three direct impacts by a vehicle moving at 65 miles per hour (105 km/h) whose bumper height was approximately 20 inches (500 mm) above ground.

(b) Following the three impacts, the channelizers were inspected and found to have:

(1) Only negligible damage to the impacted vehicle and no injury would have been sustained by occupants.

(2) No hazard created by any separation of the channelizer from its snap-on base with ballast.

(3) No part of the unit or ballast trapped under the vehicle.

(4) No permanent deformation or damage to the channelizer that impairs its function or physical appearance which renders the channelizer unusable.

**1063.2.3.1.1** Upon satisfactory submittal of a manufacturer's certification, the brand name or model number will be placed on a prequalified list and will remain on the list as long as the brand name or model number does not change and continued satisfactory results are obtained. A new certification shall be provided upon any modification of the channelizer or any change in the formulation of the plastics used in its manufacture.

**1063.2.3.2** The reflectorized sheeting supplier shall submit to the Division Engineer, Materials, a manufacturer's certification stating that the reflectorized tape conforms to all of the applicable requirements of these specifications, including a statement that the reflectorized sheeting is intended for use on flexible channelizers. Samples of the reflective sheeting shall be submitted by the tape manufacturer for approval, along with typical test results indicating the material meets the requirements for Type 2 reflective sheeting.

**1063.2.3.2.1** Upon satisfactory submittal of a manufacturer's certification and completion of any tests required, the sheeting will be placed on a prequalified list for use on flexible non-metallic channelizers as long as satisfactory results are obtained.

**1063.2.4 Basis of Acceptance.** Channelizers furnished under this specification will be accepted for use on the basis of brand name or model number provided they are on the prequalified list and have an approved reflective marking. If requested by the engineer, the supplier of the channelizers shall furnish satisfactory proof for identification of the reflectorized tape.

## SECTION 1066

### MORTARS AND GROUT

**1066.1 Mortars and Grout.** Mortars and grout shall be mixed in small quantities as needed, and shall not be retempered or used after they have begun to set.

**1066.1.1 Mortar For Pipe Joints.** The mortar shall consist of one part portland cement and two parts of approved clean sand, by volume, mixed with sufficient water to form a plastic mortar.

**1066.1.2 Mortar for Grout.** Mortar used for grout shall consist of one part portland cement and three parts approved clean sand, by volume, mixed with sufficient water to form a grout of proper consistency.

**1066.1.3 Mortar For Rubble and Brick Masonry.** The mortar shall be composed of one part portland cement plus 10 percent, by volume, of hydrated lime and of two parts approved clean sand by volume. Hydrated lime shall be Type N, conforming to the requirements of ASTM C 207. After the dry materials have been thoroughly mixed, water shall be added and the mixture shall be turned and chopped by hand or mechanical methods until a stiff mortar results. Mortar shall not be mixed more than 30 minutes in advance of use, and retempering will not be permitted. Mortar for pointing shall be mixed in the proportions of one part portland cement to one part sand by volume.

**1066.1.4 Expansive Mortar.**

**1066.1.4.1 Aluminum Powder.** The mortar shall consist of one part portland cement and three parts approved clean sand, by volume, mixed with sufficient water to form a stiff plastic mortar. Unpolished aluminum powder at the rate of 4 grams per sack (1 g/10 kg) of cement shall be thoroughly dry mixed with the cement before incorporation with other ingredients.

**1066.1.4.2** Upon approval by the engineer, other expansive mortars may be used. The expansive mortars shall be free of metallic additives, shall not contain more than 0.02 percent chlorides by weight (mass) and, when subjected to a pull out test, shall equal or exceed the results of tests made using the material specified in [Sec 1066.1.4.1](#).

## **SECTION 1070**

### **WATER**

#### **1070.1 Water.**

**1070.1.1** Water for use in mixing and curing concrete, and in mortar and grout, shall be reasonably clean and shall be free from injurious quantities of oil, acid, alkali salt, organic matter, vegetable matter or other deleterious substances. Autoclaved bars, made with the water and a cement which shows satisfactory soundness when mixed with distilled water, shall show an expansion not to exceed 0.5 percent. The time of set of cement pats made with the water shall vary not more than 10 percent from the setting time shown by pats made from the same cement and distilled water. The tensile strength at seven days, of 1:3 mortar made from cement, standard Ottawa sand and the water being tested shall show a reduction of not more than 10 percent of the tensile strength developed by 1:3 mortar containing the same cement and sand and mixed with distilled water.

**1070.1.2** Water approved by the Missouri Department of Natural Resources for drinking purposes may be accepted without being tested. Requirements for testing water for mixing or curing purposes may be waived if in the judgment of the engineer, the water is considered satisfactory for the purpose.



## SECTION 1071

### ASPHALT RELEASE AGENTS AND FIBER ADDITIVES

**1071.1 Scope.** This specification covers asphalt release agents for use in coating truck beds and bituminous mixture admixtures.

**1071.2 Asphalt Release Agent.** The asphalt release agent shall not be detrimental to bituminous mixtures and shall not dissolve asphalt when applied to the truck bed.

**1071.2.1 Physical Properties.** The following physical properties shall be determined.

**1071.2.1.1** The weight per gallon (mass per liter) shall be determined in accordance with the requirements of AASHTO T 59, Sections 105 to 110.

**1071.2.1.2** The percent solids shall be determined in accordance with the requirements of ASTM D 1644, Method A.

**1071.2.1.3** The pH of the undiluted agent shall be determined by appropriate methods.

**1071.2.1.4** When tested in accordance with MoDOT Test Method T63, the asphalt release agent shall show no evidence of dissolving the asphalt.

**1071.2.2** Dilution by diesel or other petroleum products will not be allowed.

**1071.2.3 Manufacturer and Brand Name Approval.** Prior to approval and use of an asphalt release agent, the manufacturer shall submit to the Division Engineer, Materials, a certified test report showing typical ranges for weight per gallon (mass per liter), percent solids, pH and the results of tests performed in accordance with MoDOT Test Method T63. The certified test report shall show the manufacturer's name, brand name of material, lot and date tested. The manufacturer shall also submit a one quart (liter) sample accompanied by a material safety data sheet for the material. In addition, the manufacturer shall furnish information for any dilution requirements including the minimum dilution rate and special application requirements. Upon approval of the material, the brand name, manufacturer, type of release agent, dilution rate and any special application requirements will be placed on a list of prequalified asphalt release agents.

**1071.3 Bituminous Mixture Fiber Additives.** Fibers for stone mastic asphalt mixture may be either cellulose or mineral fiber and shall comply with the requirements specified herein when tested in accordance with MoDOT Test Method T60.

**1071.3.1 Cellulose Fibers.**

**1071.3.1.1 Physical Properties**

Fiber Length, in. (mm), max.	0.25 (6.0)
Ash Content, percent	13.0 - 23.0
PH	6.5 - 8.5
Oil Absorption, times fiber weight (mass)	4.0 - 6.0
Moisture Content, percent by weight (mass), max.	5.0

**1071.3.1.2 Sieve Analysis.** The sieve analysis shall meet one of the following.

**1071.3.1.2.1 Alpine Sieve Analysis.**

Sieve Size	Percent Passing by Weight (Mass)
No. 100 (150 $\mu\text{m}$ )	60.0 - 80.0

**1071.3.1.2.2 Mesh Screen Analysis.**

Sieve Size	Percent Passing by Weight (Mass)
No. 20 (850 $\mu\text{m}$ )	75.0 - 95.0
No. 40 (425 $\mu\text{m}$ )	55.0 - 75.0
No. 140 (106 $\mu\text{m}$ )	20.0 - 40.0

**1071.3.2 Mineral Fibers.**

**1071.3.2.1 Physical Properties.**

Fiber Length, in. (mm), maximum mean test value	0.25
Fiber Thickness, in. (mm), maximum mean test value	0.0002

Shot Content:

Sieve Size	Percent Passing by Weight (Mass), min.
No. 60 (250 $\mu\text{m}$ )	95
No. 230 (63 $\mu\text{m}$ )	65
Moisture Content, percent by weight (mass), max.	5.0

**1071.3.3 Prequalification and Brand Name Approval.** Prior to any use of the fibers, the manufacturer shall furnish to the Division Engineer, Materials, a sample of the fiber for prequalification and brand name approval. The sample shall be accompanied by a certified test report showing specific test results of all properties for tests performed on the same lot or batch of material from which the sample was taken. Upon prequalification and brand name approval, the fiber will be placed on a list of prequalified fibers for use in stone mastic asphalt mixtures.

**1071.3.4 Approval and Acceptance.** Approval of cellulose or mineral fibers will be based on a manufacturer's certification that the material being furnished is the same as that furnished for prequalification and brand name approval, and that the material complies in all respects with the requirements of these specifications. In addition, the engineer reserves the right to sample and test any material at destination as deemed necessary.

## SECTION 1072

### DAMPPROOFING AND WATERPROOFING MATERIAL

**1072.1 Scope.** These specifications cover material for dampproofing concrete structures and waterproofing concrete railroad bridge decks.

**1072.2 Bituminous Prime Coat.**

**1072.2.1** Asphalt primer shall comply with the requirements of ASTM D 41.

**1072.2.2** Creosote primer shall comply with the requirements of AASHTO M 121.

**1072.3 Bituminous Mop Coat.** The bitumen shall consist of asphalt or coal-tar bitumen. The type of bitumen used for mopping shall be the same as that used for treatment of the fabric.

**1072.3.1** Asphalt shall comply with the requirements of ASTM D 449, Type II.

**1072.3.2** Coal-tar bitumen shall comply with the requirements of ASTM D 450, Type III.

**1072.4 Fabric.** Bitumen-treated cotton fabric shall comply with the requirements of ASTM D 173.

**1072.5 Asphalt Plank.** Asphalt plank shall comply with the requirements of ASTM D 517.



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